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## THE BRITISH TRANS-GREENLAND EXPEDITION, 1934: *A paper read at the Evening Meeting of the Society on 21 January 1935, by*

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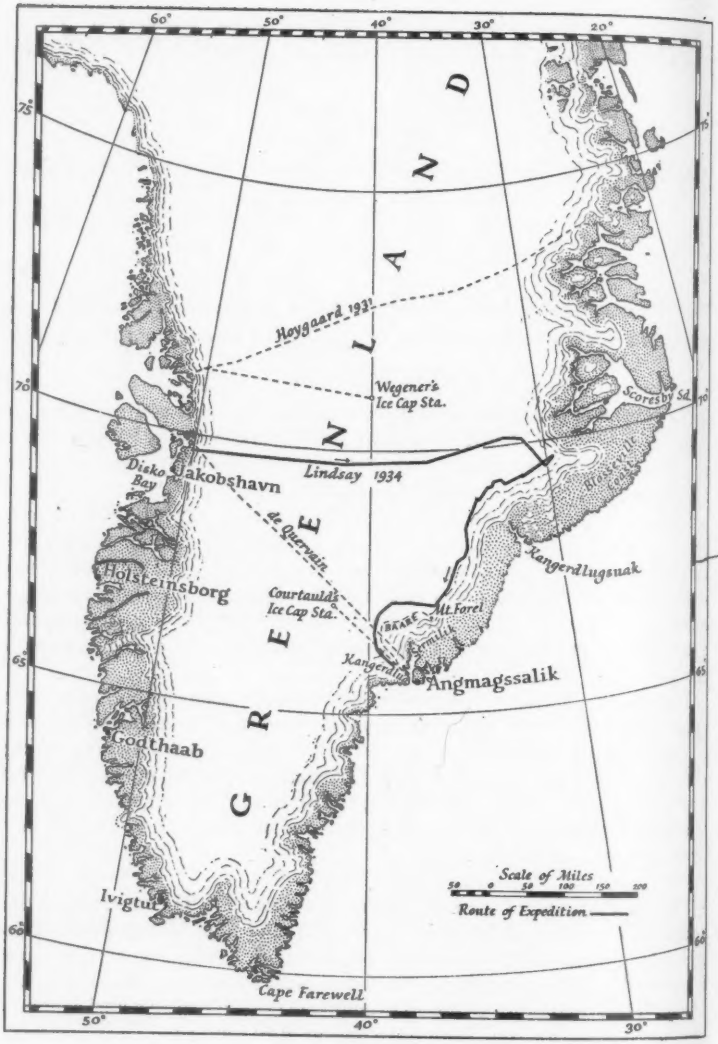
IN 1930 the mountainous country behind the coast from Mikki Fjord to the Angmagssalik District was seen for the first time by Watkins in a seaplane. In particular a high range of mountains tentatively called the New Mountains was seen to the north of Kangerdlugsuak.

Subsequent flights over this sector of the coast were made by Rasmussen, Lauge Koch, Von Gronau, and Lindberg. The first named made an aerial survey and in 1934 the Geodetic Institute of Copenhagen brought out a map of the mountain country north of Kangerdlugsuak and stretching about 30 miles inland. No survey was made of the western limits of the mountains and there were no astronomically fixed points for an aerial survey except those on the coast.

The western boundary of the mountains between Scoresby Sound and the Angmagssalik District was known only at the extreme southern end, the Mount Forel panorama having been seen by de Quervain during his crossing of the ice-cap in 1912, and that region having been visited and surveyed by Stephenson's party of the British Arctic Air-Route Expedition in 1931. It was apparent that the western limit of these mountains could be defined only by an ice-cap sledging party.

The main purpose of the expedition was to make the first survey from the west of the mountains between Scoresby Sound and Mount Forel. This region is approximately 350 miles in length, and as no man had set foot there it appeared to be the longest stretch of unexplored country within the Arctic Circle. The expedition also hoped to complete the last two principal contours of the map of the ice-cap. Both these objects were fulfilled.

The organizer of the expedition, after a journey across Central Africa in 1929, was in Greenland in 1930 and 1931 as a junior member of the British Arctic Air-Route Expedition, and was one of the party that crossed the ice-cap to Ivigtut. Like the British Arctic Air-Route Expedition, the 1934 Expedition was a private venture, organized under the patronage of H.R.H. the Prince of


60°
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G R E E N L A N D
Høygaard 1931
Wegener's Ice Cap Sta.
Lindsay 1934
Scoresby Sd.
Blosseville Coast
Disko Bay
Jakobshavn
de Quervain
Holsteinsborg
Courtauld's Ice Cap Sta.
Mt. Forel
Kangerdlugsuak
Angmagssalik
Godthaab
Ivigtut
Cape Farewell
Scale of Miles
50 0 50 100 150 200
Route of Expedition

Wales and supported by the Admiralty, War Office, and Air Ministry, who lent personnel and instruments.

The hinterland of the east coast of Greenland between Sermilik Fjord and Scoresby Sound is not easily accessible. From the west it is guarded by a 450-mile barrier of ice, and from the East Coast seaboard by very steep mountain country intersected by badly crevassed glacier valleys. Approach to the coast is difficult and limited to a few weeks a year by the hard, old pack-ice brought down by the current from the North-Polar basin. The only party that has wintered on this piece of the coast was unable to get far inland owing to the crevasses due to the steep fall to sea-level. It was therefore decided to approach this region not from the east but from the west, by traversing the ice-cap which rises to over 9000 feet and stretches across the continent. The preliminary crossing of the ice-cap was to add 450 miles to the length of the sledging journey.

The decision to make the attempt from the west was justified by the fact that while we were in the field two expeditions made unsuccessful efforts to reach our objective from the east. The French party led by Dr. Paul Victor and the Italian party under Count Bonzi hoped to penetrate the pack-ice and then, with parties of picked climbers, to ascend the glaciers to the unknown hinterland. Owing to the pack-ice neither expedition succeeded in reaching the Blosseville coast.

For a long sledging journey it is usual to lay depots along the first part of the route during the preceding summer, but this was not in our case possible owing to the peculiar conditions of the Greenland ice-cap. The great force of the winter gales, the wind sometimes approaching 100 miles an hour for two or three days a week, causes any object on the ice-cap to be completely buried by snow-drift. One of Peary's journeys was virtually wrecked through a pemmican depot being lost in this manner and in 1931 the British Arctic Air-Route Expedition had a similar experience. A large dump of wireless stores and ration boxes was put down, and when a party went to fetch it two months later it could not be found. Direction flags marked its position to within 100 square yards, but although they probed the ground the men were unable to locate the depot.

When considerations of expense precluded the possibility of a supporting party accompanying the expedition for the first 250 or 300 miles the expedition began to be organized as an entirely self-supporting unit of three men. Three men is believed to be the best number for a long journey. As the pace of the whole party is that of the slowest man, the team must be as compact as possible. Three men should be able to include the necessary rôles of cartographer, geologist, glaciologist, meteorologist, and photographer, and three is a safer number than two, as if one man breaks down there are two others to assist him. The other two men chosen were Andrew Croft, as photographer, and Lieut. A. S. T. Godfrey, Royal Engineers, to be in charge of the navigation and survey. Neither of them had any previous experience of polar travel, but Croft was a good skier and climber. The average age of the party was twenty-six.

Croft was sent on ahead to spend the preceding winter making preparations in West Greenland. He was charged with four vitally important tasks: (1) To

choose the place of ascent to the ice-cap; (2) to put a depot of nearly 2 tons of dog food at the edge of the ice-cap; (3) to select the best forty-three sledge-dogs; and (4) to learn to be an expert dog-driver. Nobody could have done these jobs better than Croft did; that without previous experience he managed to do them at all is remarkable. To show how hard he worked it is only neces-

*Route of the Expedition from Jakobshavn to the ice-cap*

sary to say that during the winter he sledged over 3000 miles and learnt two languages, Danish and Greenlandic, in order to be able to give the expedition better service.

The other two members sailed from Copenhagen in the Danish Government ship, *Gertrud Rask*, 400 tons, on April 10. She was due to reach Disko Bay before the end of the month, but as she was held back, first by heavy

*1. Sledging down on to the pack-ice in Eke Bay*

*Photographs by Andrew Croft*

*2. Just after leaving Halibut Camp*

storms and then by bad ice conditions, the voyage took three weeks longer than scheduled. This delay proved to be more serious than was realized at the time. Severe head winds were encountered on seventeen out of nineteen days, during which time she rolled almost incessantly through 70°—measured on an instrument for that purpose in the engine-room. Sleeping was not easy to those unaccustomed to standing alternately on their heads or their feet in their bunks. Jakobshavn was reached on May 20.

*The Ice-Cap Crossing*

After four days at Jakobshavn the expedition left for the north on May 24, in five rowing-boats. Our immediate objective was "Halibut Camp," Croft's depot 2000 feet above sea-level at the edge of the ice-cap in lat. 69° 45′ N. Two days before a start could be made the ice in Ata Sound became unsafe for heavy sledges. This was a sad rebuff as it meant a troublesome overland sledging journey from Pakittok Fjord instead of a fast gallop up the Strait and round the point to Eke. There was no question of waiting until a boat could reach Eke, as that would not have been possible for several weeks.

Although the ice in the fjords and lakes was still thick, the sun had melted away the snow on the hills to such an extent that we had to sledge on grass and rock for 75 out of every 100 yards. Although Croft had sledged the 2000 lb. of dog-pemmican required for the journey to Halibut Camp during the spring, with our three Nansen sledges, man-food, camp requirements, and instruments we still had another 1000 lb. of equipment to transport to the ice-cap. Most of what little snow was left was wet and soft, causing the dogs to sink in deep. As the route frequently crossed scree slopes and moraines it meant pulling the sledges over huge boulders and running a big risk of damaging their loads. There was considerable doubt whether Eke could indeed be reached; everything depended upon whether it would be possible to sledge across the southern side of the bay just east of Kimmilivik. If this were not possible many days would have to be spent in rounding a precipitous slope above it. As we had been unable to carry with us enough dog food for such a delay we should then have had no choice but to return. Owing to our ship having arrived three weeks late, we had been properly caught by the spring thaw. A ghastly fiasco seemed imminent.

At the start of our journey we were accompanied by seven Greenlanders, thus making a party of ten men with nine sledges and eighty-six dogs. The natives worked well at first, but after the fifth day three of them insisted upon going home, and even the offer of double wages was no inducement to them to stay. This was a great blow to us, more especially as the others began to lose their enthusiasm. However our spirits went up proportionately when we found that we could cross the ice in a corner of the bay. We had a rough journey over the frozen pack-ice, but reached Eke safely. From there it was a steady uphill grind over mountains and frozen lakes; and again it was a race not only with diminishing dog-food but also with the homing instincts of the Greenlanders, who daily threatened to leave us. It was a great relief when at last we reached Halibut Camp early in the morning of June 3. This point was by the side of a lateral moraine, at the edge of the ice-cap and 2000 feet above sea-level, and there we had 1800 lb. of dried halibut in addition to the

*Sledging by night in the first part of the crossing*

dog-pemmican for the journey. We spent a week at this camp in order to rest the dogs, and as the ice-cap rose steeply in ridges of slippery ice we took the opportunity to relay all our stores and equipment to a point 5 miles farther in and another 1000 feet higher. From this advanced depot the upward slope was almost imperceptible and the surface consisted of hard wind-swept snow with no more ice ridges.

During the first of these small depot-laying journeys we watched carefully for crevasses, but none we crossed was more than a foot wide. We had however to steer a course two points south of our true direction to keep clear of disturbances at the back of the big Ekip Sermia Glacier. The way to the depot we marked with red flags every half-mile and the dump itself with a huge black flag that could be seen nearly 2 miles away.

Halibut Camp was a somewhat tiresome place, for during six days out of the seven that we were there we had a strong, warm Föhn wind. We left it on June 10, and were glad to get started, for that moment was the culmination of three years' thought and preparation.

From our advance depot 3000 feet above sea-level the ice-cap had appeared to rise gently and there had seemed to be no reason why we should not proceed from there with full loads and travel fast. We now experienced an excellent example of how easy it is to be caught out by sudden changes in polar weather. Two days before we left Halibut Camp we had a rainstorm. In thirty-six hours all the snow in sight was washed away, exposing blue, crevassed ice-ridges, and the intervening valleys were full of ice-cold snow slush.

The following week was the worst any of us had ever experienced. Always wet to the skin, we had to relay our heavy loads through morasses often waist deep, a process extremely exhausting to men and dogs. Although the scientific instruments were somehow kept dry by the Sorbo-rubber lining to their boxes, one camera was ruined and a portion of the man-food contaminated through tins having been indifferently soldered. The ridges between the swamps were seamed with crevasses, in which we had the misfortune to lose five dogs. Several more went down, but these we recovered by pulling them up on their traces or lowering a member of the expedition at the end of an alpine rope. We experienced great difficulty in persuading the dogs to wade or swim the streams. They would cower shivering on the banks until one less timid than the rest could be induced to lead the way.

We started our eleven weeks' rations on June 16; but almost at once decided to extend their scope by making each seven-day box last for eight days in order to have longer for the survey period. This reduced the ration to 26 ozs. a day, which proved insufficient, so we increased it with a daily allowance of dog-pemmican. Dog-pemmican makes one smell and gives one indigestion, but none the less we were most grateful for it.

It was a great relief to us when, on June 18, we reached a height beyond the strong spring thaw and were able to travel fast. During the first week we had ideal going, the surface melting in the day-time to freeze at night into an iron-hard crust, over which the sledges glided like a skate on ice. We covered 115 miles in five nights before lying up for an astronomical observation necessary for navigation. After this the pace got slower, and we only travelled 97 miles in another similar period. By this time a height of nearly 9000 feet

*4. Typical basalt piles north of Kangerdlugsuak*

*5. The beginning of a blizzard*

7. *Crevasse in the Kangerdlugsuak basin*



6. *Basalt outcrop at the end of the crossing*

had been reached and less satisfactory conditions were experienced. The going was not so good and the weather fairly cold, the temperature falling to minus 20° F. during sledging hours. We changed over to day travelling, but were not able to keep up the speed of the first fortnight.

The dogs had by now been working for six severe weeks, and having covered 250 miles without seeing anything ahead but a desolate waste of snow, they were somewhat listless. Their state of mind was each day reflected in the mileage. We considered increasing our sledging hours in order to maintain the pace, but it is doubtful whether this would actually have been possible. Indeed, considering the condition of the party in a later stage of the journey, it would possibly have been wiser to have slightly reduced them. We travelled for nine hours daily, but with striking and pitching camp and cooking we were working for all of a sixteen-hour day.

Our greatest problem at this time was to get the leading team to pull hard with nothing to interest them ahead. On July 11 we put everything on to two sledges; we did not however abandon the third sledge but trailed it behind us, thinking that if later we met crevasses it would be better to have our valuable eggs in three baskets instead of in two. The load of the third sledge had by this time been reduced with the consumption of dog-food and man-food from 1000 lb. to about 750 lb., and this we were able to divide between the other two sledges. This procedure meant very hard work, starting sledges weighing about 1150 lb. (by swinging the front of them from side to side); but it left one man free to ski ahead of the leading team, which enjoyed being led and pulled well behind him. The hours on ski in front of the party were the best on the ice-cap, except those spent eating. One could for a time get away from sledges and dogs and be alone with one's thoughts. Ski were worn for 950 miles; without them the journey could not have been undertaken.

On July 11, after twenty days' travelling, we had reached a height of 9700 feet above sea-level,[1] and there remained only 110 miles of the crossing to complete. This we hoped to do very quickly with the help of a following wind and a drop in height. Now however we experienced a slight foretaste of the really bad weather that was to be our fate for the second half of the journey, and to detract from its scientific results. From July 12–15 we had three days of blizzard, which confined us to the tent. This had a bad effect upon the surface, so that once more the pace decreased. However on July 20 we sighted land at last, a snow-covered peak far away to our right. No sailor has ever made a more welcome land-fall. On July 21, having sledged 470 miles from the morasses and, counting relaying, about 650 in all from Pakittok Fjord, we established our first survey station in lat. 70° 05′ N. and then turned south-east. The crossing was over. Later we computed that our daily average was 18·4 miles on travelling days.

*The Survey Period*

We were now at the northern end of our objective, the 350 miles of uncharted mountain country. Kangerdlua Fjord, where our next supply of food was waiting for us, in Watkins's base hut of 1930–31, was 550 miles away. We

[1] All heights are subject to possible correction. They have not yet been fully worked out by the Meteorological Office.

now had to follow the trend of the land to the south, studying its conformation and mapping it in as great detail as possible consistent with the limitations imposed by our ever-decreasing food supplies.

The first land we saw after the desolation of the ice-cap crossing was a typical Alpine formation to the north of us. We had often speculated upon the appearance of our land-fall, wondering whether it would be blue, black, or russet-brown rock, or some entirely ice-covered feature. Little did we expect to be greeted by a remarkable miniature of the Eiger. This Swiss formation was soon to be replaced by less interesting basalt, and it was not until we were south of Kangerdlugsuak Fjord that we were to meet it once more.

As soon as we started travelling south-east we found ourselves crossing a peculiar series of hollows and ridges caused by the conformation of the land underneath the ice. These depressions were striking on account of their size, and it is believed that they do not occur elsewhere. We would cross a ridge to find ourselves descending abruptly, 500 feet or 1000 feet, down a slope so steep that it was necessary to traverse it or put a drag-rope under the runners of the sledge. Our course would take us 5 or 10 miles along the bottom of the hollow, after which our best efforts would be needed to climb up again. In contrast to this was a number of completely rounded ice-cap hills, too large and too high to be classed as hummocks. A good view could always be obtained from the top of them so, whenever possible, we used them for our survey stations.

One of these eminences will always remain in our memories. Having climbed somewhat laboriously to the top from the ice-cap side we were confronted by a magnificent vista of mountains to the south, south-east, and south-west. Range upon range stretched before us; peak after snow-clad peak stabbed a cloudless sky. We decided to stop for astronomical observations, but before we were able to take any the weather broke and we found ourselves confined to the tent for two days in a snowstorm. During such periods of enforced and prolonged inaction the deerskin rugs providing an insulation between our eiderdown sleeping-bags and the ice beneath used to become very wet with condensation. On the evening of the fourth day, while we were making an effort to dry them by hanging them up in the peak of the tent and burning two Primus stoves underneath them, the weather suddenly cleared. We went outside to make a theodolite observation and to take photographs. We rolled up the sleeping-bags and pushed them to the back of the tent; the Primuses were pumped up and left alight in the middle of the floor, well clear of everything.

Some time later somebody smelt burning, and saw smoke belching forth. It was only a matter of seconds before the fire was extinguished, but only a few seconds more would have been sufficient to cause a disaster. A few holes were burnt in the canvas, which was badly scorched. The only explanation of the origin of the fire is that the heat swelled the down inside one of the sleeping-bags, causing it to capsize over the Primuses. The damage done was trivial, but had we been standing a few yards farther away we should have lost the tent with almost everything we possessed inside it. We were at the time 450 miles from the end of the journey.

Next day we travelled north-east to establish a survey base on an invitingly high ridge. No sooner had we pitched our new camp than a gale started which

lasted for three days and three nights. The wind never dropped below 30 m.p.h. and most of the time was very much stronger. We were by this time thoroughly disgusted with the weather, for during the eleven days that we had spent in this region less than three had been fine. There is a certain irony in coming so far with such difficulty to map a country and then to be unable to see it. Although we had an adequate margin, at any rate on paper, for the distance ahead of us the weather could scarcely be said to inspire confidence and the condition of the party was hardly satisfactory. The crossing had taken far more out of us than we had realized at the time, and our sleeping hours had lately suffered. We were travelling by night, as the surface was not so good in the day-time, and we would sometimes turn in at 7 a.m. to get up again two hours later for the morning L.M.T. observation.

On the so-called days of rest there was always a lot to be done: a glove or harness to be darned or stitched, a whip handle to be spliced, a navigation computation to be worked out. These jobs never came to an end. So although we were now travelling on good surfaces with lightened sledges and were exhilarated by having reached our goal, we were in a wretched state of permanent fatigue. One would enter one's sleeping-bag worn out, to wake up no less tired a few hours later and wondering how one would manage to get through the day. During the three days' blizzard, while the snow volleyed and drummed against the side of the tent, we did some serious thinking. Fresh calculations were made about the rations and the mileage ahead of us, and we decided on account of the weather to extend slightly the survey period and cut down correspondingly the provision made for the 200-mile run home.

Slowly we made our run southward, mapping and photographing the mountains, and collecting geological specimens where possible. Great praise is due to Godfrey for the painstaking manner in which he carried out the survey in spite of the conditions under which he was working. Only those people who have themselves attempted similar work in the face of cold, hunger, and at times almost overpowering fatigue, can properly appreciate his work.

The day's run would vary from about 25 miles in fine weather to as little as 10 or 12 miles in deep going or in a snowstorm, the fatigue experienced always being in the inverse proportion to the distance covered. During the last 400 miles we sometimes had great difficulty in getting the front team to pull ahead, for the dogs had ceased to be interested in a man leading on ski. That we managed always to keep them going in the face of the greatest reluctance on their part was entirely due to the brilliant driving of Croft. The word "brilliant" is used advisedly. Croft had been sledging all through the winter with the best drivers in the country, and by the end of that time had reached their own high standard of proficiency. There are probably not more than half a dozen other men in the world who could have driven those dogs at that stage of the journey. Without Croft's driving our transport system would have collapsed, and we would have had difficulty in completing the journey.

Travelling in bad weather had its exciting moments, particularly for the man leading on ski. Down the steep slopes of a hard wind-blown surface it was difficult not to get out of control, while all the time one was watching like a hawk for any unseen menace ahead and wondering whether it would be possible suddenly to stop the dogs galloping at one's heels. On one of these

occasions we came to a halt, only just in time, at the brink of an ice-fall with a sheer drop of 2000 feet to a glacier below. Racing downhill was good sport, but we were afraid of breaking up the sledges, an event which might have placed us in a critical position. We had already partially smashed one of them in this manner, the man behind it being lucky to escape without a broken leg.

We saw two remarkable things during this part of the journey. One was a rift in the ice, several miles in length, 20 feet or 30 feet broad, and of unknown depth. It stretched across our front, and with its parallel sides looked for all the world like a monstrous canal. Though technically it must be called a crevasse it was not where one would expect it, for it crossed a flat piece of ground far from any ridge and far from other signs of ice disturbance. On the whole we had little trouble with crevasses; most of those we met were in the Kangerdlugsuak basin; gigantic specimens sometimes large enough to swallow a battleship. The other remarkable thing was the fresh tracks of a fox travelling inland, 100 miles from the coast. We knew that, like us, he must have been short of food and he had our sympathies.[1]

Mount Forel, which had been reached in 1931 by Stephenson's party of the British Arctic Air-Route Expedition, was the southern limit of our survey. As soon as we could place it on our embryo map we were entitled to cut and run for our food depot on the coast. Approaching Forel, we had to climb considerably until, when we were about 20 miles north of the mountain, we realized that we had found the highest part of the ice-cap and were camping at 10,400 feet, a greater height than any previous polar expedition.

*The Run Home*

It was a relief when, on August 26, we reached the vicinity of Mount Forel. This region had been surveyed before, so now it only remained for us to complete the journey by sledging 200 miles to the fjord where Watkins had built his base-hut in 1930. There we should find a cache of food, and Eskimos to take us in their umiaks to Angmagssalik. The ultimate issue was in no way uncertain, since we had thirteen days' food, on the reduced scale, and twelve sledge dogs. However we were anxious to reach the coast as quickly as possible, for we were by this time none too fit, and feeling both the height and the cold. Being over 10,000 feet above sea-level we would start sledging in minus temperatures each morning, and as it was always considerably colder at night one would wake up to find the inside of the sleeping-bags and the walls of the tent covered with hoar-frost from the frozen condensation of one's breathing. The summer was over. The ice-cap no longer seemed such a desirable place.

We started off in high spirits and, except for a cold north-north-east wind, had nothing to complain of for the first two days. Then the wind strengthened into a gale, but as this came from behind us we were still able to travel. With drift-snow sweeping over the dogs and sledges, we went forward and covered 46 miles in two days of blizzard. We thought that for once we had scored off the elements; but we were wrong, for the gale cut up the surface into large iron-hard wind-drifts which made skiing both difficult and exhausting. Even

[1] In 1930 the observers at Wegener's ice-cap station, 250 miles from coast, were visited by a fox which stayed nine days in the vicinity of the station, and then disappeared.

*8. Heavy going north of Mount Fo*

*9. Looking across the Kangerdlugsuak basin towards a glacier (in gap left centre) leading down to the Fjord*

*10. Camp north of Mount Forel, partly visible on the extreme left*

worse was to follow, as the blizzard was succeeded by a warm, typically Föhn wind with an overcast sky, snow, and diffused light. The surface became sticky, ski were balling up, and the teams began to lose heart. The snow was soft and wet, as one would expect it to be in spring, as near to rain as possible at 7000 feet. Ski became impracticable; one sank in deep with every stride. Worst of all, because it was so persistently overcast, we could get no astronomical observations for navigation. The weather had now been consistently bad for six weeks, to the detriment of the map we had been endeavouring to make.

Very big crevasses in the valley behind the head of Sermilik Fjord forced us to make a wide detour to the west and south-west. We were aiming for the site of the Big-Flag Depot of 1930–31, from which I hoped to recognize landmarks. When finally we were able to take an observation and fix our position we found that we were about 30 miles south-west of the old depot and about 45 miles from the end of the journey. Owing to crevasses it was only possible to reach our fjord from one direction and good visibility was essential. We had only four days' food left; the prospect of lying up indefinitely, waiting for fine weather, did not appeal to us. For the first day after the observation prospects were bad. In the grey misery of diffused light we plodded on, longing passionately for the sun. Just before camping we caught a glimpse of land ahead: a small, dark-blue peak on the horizon.

Next morning we awoke to the joy of a clear sky, and to our astonishment the sea was in sight, far away below us. The rising sun glinted on the icebergs so that in the dawn they looked for all the world like the lights of ships seen from a hill behind the harbour. We did not take long in getting off. The dogs could now see the land; they pricked up their ears and raced towards it. As we lost height, more and more features came in sight. Without any undue difficulty we reached Bugbear Bank, the steep ice-fall at the head of a dead glacier. In order to descend it under control we loosed the dogs—having been tied to the sledges since May 24 they scarcely knew what to make of it. As always in 1930 and 1931 we got down this slippery and in places almost perpendicular slope by no means under control and rather surprised to find we had not smashed up either ourselves or the sledges.

At the bottom of the glacier we were met by Eskimos, who had brought a boat to row us across to Watkins's old base-hut. There we gave the dogs a treble feed from an old case of dog-pemmican that we had picked up at the top of Bugbear Bank. It was a great joy to see them able to eat without stint for the first time for so long. It is almost impossible to speak too well of these dogs; they had been in harness for fifteen weeks and had covered about 1200 miles. Starting with very heavy loads, they had pulled their sledges in all weathers and on every kind of going, over rock, grass, pack-ice, fjord-ice, and glacier-ice; through morasses and mud and fast-running rivers, and through every condition of snow. Their devotion was only equalled by that of my two companions, who, likewise, were always beyond praise. No leader has ever been better served.

Our meeting with the Eskimos marked the end of our endeavour; henceforth we were but passengers. We had arrived after 103 days' sledging with $2\frac{1}{2}$ days' man-food and 1 day's dog-food in hand. The total length of the

journey, counting relaying, was about 1200 miles, for 1100 of which we had been a self-supporting unit.

We were overjoyed to reach the hut, the largest room of which we were to share with twenty-four Eskimos. There we found a box of provisions and, for the first time for three months, we were no longer on rations. It now seemed strange to us to pour porridge out of the pot instead of doling it out spoonful by spoonful, and to help oneself to sugar without counting the lumps. Although we always had sufficient food on the ice-cap we seldom finished a meal without wanting to eat it all over again. The subject of food filled a very large part of our thoughts and conversations.

Our arrival at Angmagssalik was something of an event for all concerned. For the inhabitants of that obscure outpost it meant visitors. There are only five Danes there and they live a lonely existence, for their tour of duty is five years at a time, which is only broken once every twelve months by a ship bringing them supplies and the annual mail. For us it meant letters and the privilege of taking off our clothes for the first time for fifteen weeks.

The pack-ice was exceptionally early this year. On our arrival we were greeted with news of ships farther north being beset for many days in places which should have been ice-free at that time of the year. We spent most of the following week either on a hill-top where we watched the ice drifting down from the north, gathering with an alarming rapidity, or in the wireless office wirelessing frantically to tell our fishing vessel to hurry. The *Jacinth* arrived on September 15; had she been half a day later we should have been forced to stay in East Greenland for another twelve months. Three weeks later we stepped ashore at Aberdeen.

*Principal Topographical Conclusions*

So much for the narrative. The geographical results may now be considered.

L. R. Wager has summarized in a sketch-map the contours of the inland-ice as postulated by exploration up till the activities of this expedition (*Geol. Mag.*, lxx, no. iv, 145–156). The last and highest contour-line, that of 3000 metres, was drawn from the results of Wegener's ice-cap station (1930–31), the Mount Forel journey of the British Arctic Air-Route Expedition (1930–31), and Hoygaard's crossing (1931). Except that Stephenson's party of the B.A.A.R.E., during an attempt to reach the summit of Forel, were able to look north-west from a height of 3200 metres, the knowledge gained by these expeditions was of necessity confined to the limits of their journeys. The 3000-metre contour-line was drawn respectively through the most easterly, northerly and southerly points that they reached in the territory under consideration. Nothing was known about the height of the inland-ice inside this contour ring, *i.e.* an area of more than 100,000 square miles, between lats. 67° N. and 72° N., and east of long. 40° W. It was therefore considered to be of great importance to obtain accurate height determinations as the proposed sledge journey would twice cross the unknown sector of the ice-cap that lay inside the 3000-metre contour-line. A battery of three aneroids was taken; one of these ceased to function at the start of the journey, but the other two, a Watkin Mountain Aneroid and a Negretti and Zambra, followed each other

*11. Curious ice-formation between Kangerdlugsuak and Forel* (*see p. 407*)

*12. Closer view of the same phenomenon*

*13. Continuation of the formation to the south*

*14. First view of the sea at the end of the journey*

*15. Forcing a way through the pack-ice to the "Jacinth"*

excellently throughout the journey (*vide* Appendix II). That the two aneroids gave such satisfactory readings in spite of the jolting inseparable from sledging is due in a large measure to the fact that their case was lined with Sorbo rubber ½ inch thick, and that the inside of the instrument box was also lined in a similar manner. This innovation should be followed by all subsequent expeditions.

The last principal contours of the ice-cap as postulated by the expedition will be shown on the map to be published later with our scientific appendices.

The narrative of the expedition describes the difficulties caused by thaw water experienced at the start of the ice-cap journey. The features encountered—lakes, morasses, hummocks, rivers and crevasses—are in summer a regular marginal feature of the ice-cap, since the gradient and excess of precipitation at the lower levels make it the region of predominant movement and supply. The ice hummocks are an expression of a state of equilibrium between the melting by solar radiation and by warm air, the rays of the sun being more readily absorbed by water than reflected by dry ice so that their power is greatest in the already existing depressions where the thaw water gathers. In addition the rays of the sun have a more powerful effect upon ice on a slope, and the whole has an intensifying effect upon the inequalities of the surface. The hummocks increase as the season advances and vary greatly between the various parts of the ice-cap edge. Rymill at the end of his crossing to Holsteinsborg (1931) described the hummocks as varying from 12–15 feet to 40–50 feet in height. Ejnar Mikkelsen in his marginal crossing in North-East Greenland (1910) found the surface very hummocky over long distances, but we, like de Quervain in this region in 1912, were not much troubled with hummocks. We were too early in the season for the crevasses to be broad; those we met were almost without exception transversal. Although one or two wide and very fast-running rivers and a few lakes were seen, it was the valleys of snow slush that had not yet drained off into lakes and rivers that caused the greatest difficulty. The extent of the ravages of thaw varies as the season advances. Thus we, in June, passed the last swamps and crevasses at 4000 feet above sea-level, 12 miles from the edge of the ice-cap (although it is worth noting that 10 miles farther we crossed a remarkable ravine eroded during the previous summer by a watercourse that must have been very big in order to have preserved its outline since the autumn, in spite of precipitation and drift-snow), whereas de Quervain, a month later than us, had found crevasses 90 miles from the edge of the ice-cap, and very large crevasses at a distance of 80 miles.

Between 4000 feet and 5000 feet the valleys were still marked and the slopes were steep. From about 5000 feet this became less and less noticeable until at 7000 feet the slope was almost imperceptible. Both Nansen and de Quervain noticed big valleys near the western edge of the ice-cap and de Quervain counted ten of these steps in the first 95 miles of his crossing between 2000 and 6000 feet above sea-level. Both considered these features to be a reflection of the topography below the ice, but it must be observed that there is nothing in the geological structure of the Coast to suggest a north and south direction of the main features. Certainly these valleys are very considerably more pronounced than the undulations, usually between 1 and 2 miles from

crest to crest, that were observed on the way up to Watkins's ice-cap station nearer to the east coast; in the latter case these features are probably caused by the strong winds drifting the snow from place to place, causing the undulations to shift perpetually like desert sand.

Between 4000 feet and 5500 feet the surface thawed in the day-time to freeze into an ice-crust at night so that it was not possible to drive the poles of the tent into the snow without first piercing a hole with an ice-axe. The ice surface became more and more covered with small patches of soft snow until at about 6500 feet it ceased to thaw at any time of the day, and the surface consisted of névé chiselled into small sastrugi bearing the direction of the prevailing wind. The ice-crust surface was not met again until the last day of the crossing. This crust can assist a study of the lamination of névé. In the ablation periods at the lower levels only porous ice is to be found, showing no sign of stratification. Higher up, the summer ice-crust is covered in winter with a layer of snow, the surface of which the following summer will again become ice. Thus alternate layers of ice and snow are formed, and it is possible to measure the amount of precipitation, a layer of ice plus a layer of snow being one year's accumulation. The ice-crust that was found at a height of 7000 feet at the end of the crossing disappeared when we climbed again next day, and was not re-encountered until we dropped below 7000 feet in the Kangerdlugsuak basin. Later we met it again, below 12 inches of snow, a recent fall having followed the period of thaw, and again an ice-axe had to be used to make holes for the tent poles. It was sometimes necessary to dig a pit, and the ice-crust of the previous summer, about 1 inch thick, was found about 8 inches lower down.

The surface changed completely from time to time throughout the journey. In the centre the snow was fairly soft, the sledges frequently sinking in 3 or 4 inches. After periods of precipitation the going would be heavy, sometimes for many days. Sastrugi occurred to a greater or less extent nearly everywhere and varied with areas of smooth névé, soft snow and pie-crust surfaces, according to recent local conditions.

Previous crossings of the ice-cap have shown that the maximum height is nearer to the east coast than to the west. This journey has confirmed the high centre north of Mount Forel, which rises to at least 10,500, and has established it not only as the highest part of the Greenland ice-cap but also as the highest ice-plateau in the world, as far as can be at present ascertained, in view of Dr. Simpson's reduction to 9860 feet of the highest known part of the Antarctic plateau. It has also shown that the 3000-metre (9800-foot) contour-line of Wegener's ice-cap station represents a saddle farther east than has so far been postulated, since the fairly level summit of the ice-cap in the direction of our crossing stretched from points approximately 300 to 350 miles from the west coast.

From this saddle we descended 1900 feet in 110 miles to complete the crossing before establishing the first survey station and then turning south-east. The 2500-metre contour-line was passed in the last few miles of the crossing. Completing the crossing on lat. 70° N. there was a marked difference between the peneplain in front with basalt outcrops and the gneiss and schist panorama of the metamorphic complex to the north.

The extraordinary ridges and depressions encountered in the 40 miles travelled in a south-easterly direction have already been referred to in the general narrative. The writer has not seen anything like them behind the west or south or south-east coasts. The only descriptions bearing any resemblance to these broad undulations and flat, dished depressions are those of the Victoria Plateau of the Antarctic.

As the essential topographical factor controlling the height of the ice-cap appears to be the height of the coastal mountain belt through which the excess of ice has to escape (Wager, 1933) it was thought that the ice-cap would be particularly high in the corner south of Scoresby Sound, which is separated from the sea by the highest mountains in Greenland. In point of fact we never climbed much above 8000 feet in this region, though this was a fair height in comparison with the proximity to the sea.

There was no evidence of ice movement north of the Kangerdlugsuak basin. Close to the mountains the ice-sheet was not thick, as was demonstrated by numerous outcrops. There were no signs of crevasses or disturbances which would be expected in a thin ice-sheet if there was any appreciable movement, so the ice there would appear to be stationary, the forces of precipitation and denudation so nearly balancing each other that it probably changes little from century to century. This being the case it is a region not of supply but of conservation, and the majority of the glaciers that reach the coast must, in the future if not already, lead from a dead-end among the mountains and short of the inland-ice.

Very big crevasses, both transversal and longitudinal, were found in the Kangerdlugsuak basin, as was to be expected since this fjord is one of the main sources of drainage on the coast. They did not however stretch more than 45 miles inland from the head of the fjord. A remarkable rift in the ice has already been referred to. Behind the Kangerdlugsuak basin we camped on a solitary basalt outcrop. Much discussion has been made upon the relation of the ice with these nunataks. Sometimes the surface of the ice rises towards them and at other times descends in either a concave or convex slope. At other times, owing to radiation heat, the nunatak lies in a funnel-shaped depression, the ice having been melted back from it, with often a small lake at the foot of the outcrop. It has been suggested that on the west coast the nunataks are usually of the latter type, while Nansen asserts that on the east coast the surface does not generally slope down towards the nunatak. Drygalski refers to a "west coast type." In the opinion of the writer, based on observations at the edge of the ice-cap in four very different localities, there can be no such classification as a west or east coast type, the ice formation depending entirely upon immediate local conditions varying from place to place. This will be elaborated elsewhere.

Between Kangerdlugsuak and Mount Forel the curious phenomenon shown on Plate 11, greeted us in the distance, and Plate 12 shows a close-up of the same place. Plate 13 shows a continuation to the south, and almost in extension of Plate 12. The ice has been smashed up and is now much weathered. The whole feature was about the size of a large house and was perched on the end of a ridge which sloped imperceptibly towards the east and fell away sharply to the west below the feature. The ice was extremely hard and smooth,

with no sign of lamination or abrasion. No outcrop was seen. As there are no data to suggest an earthquake there can be no explanation other than ice movement over land beneath. No one has been able to identify it with a similar feature seen elsewhere.

North of Mount Forel we again crossed the 2500-metre and 3000-metre contours, close together, and camped four times at over 10,000 feet, the highest position being determined as 10,400 feet. The surface continued to rise towards the north and north-west, and must have been at least 10,500 feet. Even if it is arbitrarily assumed that the maximum error in height determination is at this point, this still appears to be the highest-known ice-plateau in the world.

It is suggested that this high centre is caused by a combination of two factors: the proximity of the high mountains in the Forel region, obstructing an outflow of ice in an easterly direction, and a high degree of precipitation which is consistent with what is known of conditions on that part of the coast.

The ice-cap between Mount Forel and Watkins's old base has already been described by Stephenson in the published results of the British Arctic Air-Route Expedition. The only points worth noting in the last stage of the journey are that the valleys above Bugbear Bank have changed remarkably since 1930, due to movement of the big active glacier flowing into Kangerdlua Fjord, and that the ice on Bugbear Bank itself has receded slightly, causing an extension of the outcrop below it.

*Acknowledgment*

The leader of the expedition wishes to express his most heart-felt gratitude to H.R.H. The Prince of Wales, its Patron, and to three individuals without whose assistance the expedition could not have taken place: namely, to General Sir Archibald Montgomery Massingberd, Chief of the Imperial General Staff; to Herr Daugaard Jensen, Director for Greenland in the Government of Denmark; and to Colonel R. V. G. Horn, then commanding 2nd Batt. Royal Scots Fusiliers.

Also to the Director of the Scott Polar Research Institute and his Secretary, to Dr. H. R. Mill, Captain Ejnar Mikkelsen, Dr. Gilbert Wilson, Dr. G. C. Simpson, Dr. C. E. P. Brooks, Lieut. E. H. Thompson, Herr Knudsen, Mr. Roger Pettiward, and Mr. J. M. Scott.

Also to those British business houses who equipped the expedition either free of charge or at a generous discount.

NOTE.—*The Appendices on Survey, Determination of the Altitudes, Geology, Meteorology, Transport, Rations, and Photography, together with the maps of the Expedition, will be published in a later issue.*

## DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: As you know, the paper to-night is on The British Trans-Greenland Expedition, 1934, led by Mr. Martin Lindsay, who is now going to give us an account of it. He is a Lieutenant in the Royal Scots Fusiliers, and it is a great pleasure to us to-night to welcome not only his immediate C.O., Colonel Mosley, who was most

sympathetic in arranging leave for the expedition, but also the distinguished Colonel of the Regiment, Lord Trenchard, himself an old Scots Fusilier. Unfortunately the Prince of Wales, who is Colonel-in-Chief of the Regiment and was also Patron of Mr. Lindsay's expedition, was unable to be present this evening.

The Fellows of this Society have very special reasons for giving Mr. Martin Lindsay a hearty welcome to-night. I will tell you why. When explorers are making plans for serious expeditions it is sometimes a help to them to be able to say that they have the support of the Royal Geographical Society. We have to be cautious in according our formal support, and in this case we considered Mr. Lindsay's plans, and considered them again, but the Society did not feel that they gave a sufficient margin of safety. All we felt able to do for him was to lend him some instruments. However he went on with his plans, with your leave or by your leave as far as we were concerned, and he has returned safely to this country after accomplishing what he set out to do. So we are all the more glad to see him here to-night. I will not detain you longer, but ask Mr. Lindsay to read his paper.

*Mr. Martin Lindsay then read the paper printed above, and a discussion followed.*

The PRESIDENT: We always like to see members of expeditions on the platform, if we can. I am sorry to say that Mr. Croft, whose beautiful photographs we have been enjoying, is not in England; but Lieutenant Godfrey, who was in charge of the survey and of navigation, is here, and I hope he will speak to us.

Lieut. A. S. T. GODFREY: I think one of the principal points of interest in the survey was the heights. The aneroid heights were carried from station to station. We took aneroid readings directly we arrived at a camp and we took them the last thing as we left it, thus presupposing that the barometric pressure stood the same while we were travelling but not when we were stationary. This was the supposition adopted by Dr. Simpson when he recomputed the heights of the Antarctic plateau. We carried the heights right through for the whole of the journey and at the end we closed with an error of 123 feet. We are not at present suggesting that our errors fall within this limit, but as the closing error was of a different order from the heights we were measuring, we suggest our heights are not wildly out. And we made another check. We compared our barometric readings with the readings at Jakobshavn and Angmagssalik for the date we were at our highest point, and the height given by that comparison was only 200 feet out from our carry-forward heights. There was no hope on the survey of making any triangulation. We had hoped to make a survey on astronomical bases continuously from the start to the finish, but unfortunately we had deplorable weather and there were two breaks in the survey. However we managed to get on an average an astronomical station every 35 miles, and we put in a compass traverse in between.

If one was doing the journey again or going over the same ground it would be worth considering doing a photogrammetric survey. I will try to explain what I mean. The idea would be to make a principal point traverse, a method used in air survey but, as far as I know, not in terrestrial survey. One would sit down for several days at the beginning of the journey and fix the position astronomically very carefully, and then one would go on taking photographs every so often, depending on how far away the mountains were, the vital thing being to get a strip of territory common to any three consecutive photos; and one would end up the survey with another fixed astronomical position. This would have the enormous advantage of providing a contour map, which was impossible for

us and is impossible ordinarily unless one takes a plane-table. Also it would save an immense amount of bother, particularly to the surveyor of the expedition who has got to turn out at each astronomical position several times a day when the rest of the party are lying comfortably in the tent! He would have a very busy time at the beginning of the survey period and at the end. Otherwise he would just be taking photographs. But the results would have to be sent abroad as there are not in England machines capable of plotting horizontal stereoscopic pairs.

The PRESIDENT: Mr. Wordie, who is one of our Hon. Secretaries and has great experience of exploration in Greenland, is present. I will ask him to add a few words.

Mr. J. M. WORDIE: It is a privilege to be asked to be the first to congratulate Mr. Lindsay on his wonderful journey. He has stirred our imagination to-night, and the way in which he has tackled the problems of distance and duration must have won the admiration of all who are interested in the advancement of Arctic travel. His journey has shown the many improvements which have been effected in recent years by which Englishmen have come to the front as dog-drivers of the first ability.

The problem of the height of the ice-cap is one of the most important of the expedition's results. It was studied by Mr. Wager after he came back from Mr. Watkins's expedition, and the map which he then made and which was shown on the screen showed what big blanks still remained to be filled in. Mr. Lindsay's track has gone right across the biggest of the blanks, and he has brought back just what we wanted to know. The height figures are higher than any previously known, and it will of course be asked how far they can be accepted as accurate. After listening to Mr. Godfrey's very modest account of how the observations were made we can be sure that he is not going to claim more than he can prove. It is a most interesting discovery, and it must be very satisfactory to Mr. Lindsay and his party to know that the results are so good and have so fully justified their plans, and that their early troubles have been merely the prelude to a very fine achievement.

The PRESIDENT: Dr. Mill you all know so well that he needs no introduction. He is our chief authority on polar exploration.

Dr. H. R. MILL: I first heard of Mr. Martin Lindsay when I was asked to review his extraordinarily racy account of Gino Watkins's expedition to East Greenland. I am delighted to find to-night that he retains the same power of attractive exposition with just the proper spice of humour to make it piquant.

Mr. Wordie has expressed admirably the opinion of a man experienced in similar conditions of polar travel. I can only speak from the point of view of a book-worm, a much less distinguished animal than an explorer. But I will say this: that when Mr. Lindsay's plans were brought before the Council of the Society I was reluctantly compelled to join with the majority in thinking that they involved far too great a risk to be approved of. And it came upon me with a horrible shock to discover that I was adopting the very attitude that the old Arctic admirals took up towards Nansen forty-three years ago when, as a young man, I felt my heart burn with indignant feelings of exasperation at the old idiots who were discouraging the fine ambitions of youth. But coming to think of it, I am not at all sure that a wholesome douche of discouragement is not the best incentive to spur on a young explorer. A man has to be set upon his mettle, and there is no more delightful outcome of effort than to prove that those whom one has been taught to respect were wrong, when this is done by carrying out to the letter the almost impossible exploits which were planned beforehand. That Mr. Lindsay has done. Upon that we must congratulate him as heartily as the

fine old Arctic admirals bore testimony to Nansen's greatness when he returned in the *Fram*.

Mr. L. R. WAGER: I should like to say that I think Mr. Lindsay's journey an extremely satisfactory one in view of the discouragement he received from most people before he started. As a matter of fact before he left England he asked me whether I thought it would be possible to travel along on the ice-cap margin adjacent to the mountains. He thought that would be a very crevassed part of the ice-cap. So, of course, he found it in the neighbourhood of the big fjords such as Kangerdlugsuak and Sermilik, but elsewhere the ground was almost uncrevassed and he travelled fast. To my credit perhaps I may say that I told him before he went that on the evidence of our Forel journey in 1930 I thought he would come across fairly easy going along the edge of the ice-cap. It was because of the fast trail here that Mr. Godfrey was able to produce the maps. These will be extremely important, especially to the Danish surveyors who have only mapped the country from the coast and are very anxious to get fixed points in the inland, which can only be obtained by such a journey as Mr. Lindsay's.

The PRESIDENT: Mr. Binney, who is a member of our Council, has been the life and soul of the activities of the Oxford University Exploration Society. I will ask him to give his comment.

Mr. G. BINNEY: I should like to add my congratulations on Mr. Lindsay's journey to those of Mr. Wordie and the others who have spoken this evening. Mr. Lindsay was faced with one great problem. He tackled the east coast of Greenland from the west side and had to get his party across the ice-cap in such good form that when they reached their objective they would still be in adequate physical condition to be able to undertake their work. That he managed to do. He not only made a magnificent journey across Greenland but was also able to carry out reconnaissance work along the east coast when he arrived there. I am very pleased to be able to add my congratulations to those already offered on his double achievement.

The PRESIDENT: Dr. Mill has spoken eloquently from the point of view of the Geographical Society and of the "old idiots" who are said to have discouraged exploration. But you must all have realized what a risk, and what a splendid risk it was that Mr. Lindsay ran, and how narrow was the margin of safety; but under Providence all of them kept fit and succeeded in accomplishing precisely what they had set out to do.

I may tell you that at the end of July or the beginning of August last year I received a telegram from an airman friend of Mr. Martin Lindsay's who had just returned from Copenhagen. He had heard a rather pessimistic forecast of what was likely to happen to the expedition. He said: "Lindsay is apparently overdue. Does the Society wish that I should go and look for him?" I replied immediately: "He is not due for another week and we have no present reason to think that there is anything wrong." So no search party went out to look for Mr. Lindsay! I know from long association with the Navy how a ship which has perhaps only taken shelter during bad weather hates to have two or three vessels sent out to look for her; and it is the same with the merchant service: if there is one thing the ships of commerce do not like it is being salved. Mr. Martin Lindsay did not want to be salved on this occasion, and it is satisfactory to know that there proved to be no need for it. I ask you to join me in congratulating him and his comrades, this very small gallant party, on the splendid task which they set themselves and on the success with which they completed it.

# SOURCES OF WATER IN THE NORTH-WESTERN SUDAN

K. S. SANDFORD

IN the following pages I propose to trace the changes in nature and origin of available water from the varied lands of Darfur, with their annual rains and thorn scrub, northward into the rainless tracts of the desert to 22° N. Here the boundary between Egypt and the Sudan formerly ran from the Nile to Tibesti, but since July 1934 the line has turned southward at 'Uweinat and the western territories have been ceded to Italy: the only notable locality within them is the important hand-dug well of Sarra. I owe my knowledge of this terrain to the last expedition led by Major R. A. Bagnold,[1] of which I was a member, and I am indebted to this Society for the award of the Murchison Grant in the same year. At a later date I returned to the western Sudan to complete these notes.

A general view of the territory shows the essential part played by the highlands of the Nile–Congo and Nile–Chad Basin watershed. Farther north this is continued through the hills of Ennedi and Erdi. The high ground is then broken: a ridge runs northward and upon it lie 'Uweinat, Arkenu, and the Gilf Kebir, low ground intervenes on the north-west of Erdi and there is a marked lowland between the northern part of the Chad Basin and the Italian sector of the Libyan Desert. Beyond it there rises the great mountain mass of Tibesti, and high ground continues northward thence to the Fezzan. East of the Nile–Congo–Chad Basin divide, and of its continuation through 'Uweinat and the Gilf Kebir, the land falls gradually to the Nile with but few intervening patches of high ground. Such detached hills as the Nuba Mountains, and the basalt hills of Meidob and others, naturally receive more rain than the surrounding plains, a distinction that we found to hold good even in the middle of the desert, in the hill-group that we traversed in 1932 east of the Gilf Kebir.

The eastward drainage of the mid-African watershed fails progressively from south to north. In the far south the tributaries of the White Nile flood annually: of these the Bahr el 'Arab is the most northerly. It is succeeded on the north by a group of streams flowing from the hills or local highlands toward the Nile which are dry for a large part of the year. They flood in the summer rains, but the water sinks into the sand before it gains the Nile. Of these the Khor Abu Habl, which the railway from El Obeid follows from Er Rahad to Tendelti, is an interesting example: normally its waters fail to reach the Nile, but there are reports of their doing so in exceptional years.

Farther north the distances attained by water flowing from the main watershed decrease rather rapidly, but in certain districts wadis adjacent to the Nile are in spate annually or at irregular intervals: such are the Wadi el Melik and Wadi Abu Dom in Dongola, the most northerly watercourses on the west bank of the river to contribute to its volume with any frequency. North of

[1] *Geogr. J.*, vol. 82, 1933, pp. 103–129, 211–235. Reference should also be made to the illustrations for the special purposes of the present paper. The title 'North-Western Sudan' refers to the frontiers up to 1934, *i.e.* including the Sarra Triangle which has been handed over to Italy since this paper was written.

Dongola surface water reaches the Nile from the west only on rare occasions. Even springs are virtually absent on the west bank north of the region, but a hot spring occurs a little south of Ukma (Akasha), and is marked on the Halfa sheet of the 1 : 250,000 Sudan map. This is doubtless the "hot sulphur spring of Okmeh" visited by R. Lepsius in 1844, and described by him in his 'Letters from Egypt, Ethiopia, and the Peninsula of Sinai' (translated by L. and J. B. Homer, London, 1853, p. 238) as follows:

> ". . . a square tower . . . has been erected over the spring, which is now called after its builder Hammam Seidna Soliman . . . the stream of water, about the thickness of a man's wrist, issues from the eastern side of the tower; on the other side, within the space of a square foot, sixteen little whirlpools rise out of the sand, and here, where the water is hottest, it is quite 44° R. (131° Fahr.). It tastes sulphurous and a white substance is deposited on the earth round the spring. Every year the river rises above it, and even the tower which stands half-way up the river bank.
>
> "Somewhat farther down the river another spring of water appears, which has a temperature of 40° R. (122° Fahr.)."

Thus the headwaters of former tributaries survive in northern Darfur; their courses to the Nile have been obliterated, but in the riverine provinces water may flow from local elevations to the river along the beds of tributaries formerly continued from the continental watershed, or along local khors and wadis.

The most northerly river valley to leave the continental watershed on its east side is the Wadi Hawa. Water is present in it probably in most rainy seasons, but there is very little indication of surface flow. East of the longitude of Bir Natrun the wadi fades out in the desert, and such water as reaches the plain from the highlands is evaporated, absorbed by vegetation or sinks into the ground. On the east side of Ennedi and Erdi deep trenches have been cut by water, but little now flows and that small quantity is held in basins at the foot of the hills. On the western side however Col. Tilho has shown that there is some surface flow towards Lake Chad, but, as in Wadi Hawa, the water sinks into the ground in the plains. The surface drainage of Tibesti appears to be of the same type as that of Ennedi, especially on the east side, but the rainfall is very slight.

*Rainfall*

In 'Uweinat, the Gilf Kebir, and neighbouring hills, rain is extremely rare, but evidently surplus of surface run-off collects in small basins, filled with sand and gravel, at the foot of the hills opposite mouths of wadis. Small superficial supplies may thus be temporarily available in rock pools and in seepages from sand and gravel, but the only considerable bodies of water lie below the static water-level, which may be at great depth: this source is immediately available in the oases as shown by Dr. Ball.[1] With the exception of this underground supply the water available to any population, whether settled or nomadic, depends on local rainfall or on flow from adjacent high ground that receives rain. Supply therefore depends on (1) the arrival of

[1] "Problems of the Libyan Desert," *Geogr. J.*, vol. 70, 1927, pp. 21–38, 105–128, 209–224; and vol. 82, 1933, pp. 289–314.

rain-bearing clouds; (2) altitude of land; and (3) to a certain extent on the temperature of the air above the sun-scorched ground. The third point is explained by two experiences near 'Uweinat. In October 1932 we saw rain falling from clouds drifting from the west: no moisture reached the intensely hot ground, it was evaporated and retained in the heated lower air. On the night of 31 May/1 June 1934, on the other hand, heavy rain fell for several hours and damaged the quarters of the Sudan Defence Force Patrol then stationed in the plain below Karkur Murr, 'Uweinat.

South of Wadi Hawa we enter the inter-tropical rain-belt and, irrespective of height or temperature of the surface, rain falls to an increasing extent southward in every year. A belt of varying width up to about 100 miles near the flanks of Ennedi, on the north side of Wadi Hawa, receives a few fine showers annually, sufficient to produce a variable crop of gizu grazing. The nomad tribes take their camels northward after the rains, as circumstances permit, and in 1932 we found enormous herds of antelope, gazelle, ostrich, and other animals ranging over it. The Wadi Hawa is thus in more than one sense the southern border of the desert. The country immediately on its south is included in the rain-belt of 100–200 mm. by Hurst and Phillips ('The Nile Basin,' vol. i, 1931, pl. 8–23 and text), but the position of the belt has necessarily been estimated by analogy with the Nile valley, northern Darfur and Kordofan, and I doubt if it stretches so far north, except in the immediate vicinity of the hills of Wadai and Ennedi, where the rainfall may exceed these figures. Even so, the wadi may reasonably be assumed to receive 50–100 mm., and west of 24° E., 200 mm. in most years. The rain falls in the hot months, but the degree of cloudiness is high, and so is humidity, evaporation thus being correspondingly reduced.

In the north-western deserts, near the border of the Sudan, Egypt, and Italian territory, if rain falls at all it may be expected from the same Atlantic winds that bring it to the south in the hot months. The degree of cloudiness is low, and so is humidity in these overheated deserts, and evaporation, as we have already seen at 'Uweinat, may entirely prevent the moistening of the ground by rain. These contrasts are shown in the accompanying table:

SUMMARY OF PROBABLE CLIMATIC CONDITIONS (BASED ON DATA GIVEN BY HURST AND PHILLIPS)

| *July–August.* | | *January.* | | |
|---|---|---|---|---|
| *NW. Region.* | *S. Side of Wadi Hawa. East of 24° E. long.* | *NW. Region.* | *S. Side of Wadi Hawa. East of 24° E. long.* | |
| 32° C. =90° F. | 34° C. =94° F. | 14° C. =57° F. | 18° C. =64° F. | Temperature, mean of day, uncorrected for altitude. |
| 29 | 23 | 45 | 31 | % Relative humidity, mean of day. No satisfactory figures: compare— Dakhla for NW. Region. Merowe for Wadi Hawa. |
| 0–1 | 2–3 | 0–1 | 0–1 | Cloudiness, scale 1–10. |
| 0–25 mm. | 50–100–200 mm. | Nil | Nil | Rainfall. Many years rainless in N.W. region. |

South of Wadi Hawa and west of long. 24° E. the summer rainfall probably rises quickly above 100–200 mm. and humidity to about 32 per cent. summer, and 38 per cent.

*Nyima Jebels, Nuba Mountains: high level alluvial basin*

*Nyima Jebels: pool at margin of basin shown above*

rain-bearing clouds; (2) altitude of land; and (3) to a certain extent on the temperature of the air above the sun-scorched ground. The third point is explained by two experiences near 'Uweinat. In October 1932 we saw rain falling from clouds drifting from the west: no moisture reached the intensely hot ground, it was evaporated and retained in the heated lower air. On the night of 31 May/1 June 1934, on the other hand, heavy rain fell for several hours and damaged the quarters of the Sudan Defence Force Patrol then stationed in the plain below Karkur Murr, 'Uweinat.

South of Wadi Hawa we enter the inter-tropical rain-belt and, irrespective of height or temperature of the surface, rain falls to an increasing extent southward in every year. A belt of varying width up to about 100 miles near the flanks of Ennedi, on the north side of Wadi Hawa, receives a few fine showers annually, sufficient to produce a variable crop of gizu grazing. The nomad tribes take their camels northward after the rains, as circumstances permit, and in 1932 we found enormous herds of antelope, gazelle, ostrich, and other animals ranging over it. The Wadi Hawa is thus in more than one sense the southern border of the desert. The country immediately on its south is included in the rain-belt of 100–200 mm. by Hurst and Phillips ('The Nile Basin,' vol. i, 1931, pl. 8–23 and text), but the position of the belt has necessarily been estimated by analogy with the Nile valley, northern Darfur and Kordofan, and I doubt if it stretches so far north, except in the immediate vicinity of the hills of Wadai and Ennedi, where the rainfall may exceed these figures. Even so, the wadi may reasonably be assumed to receive 50–100 mm., and west of 24° E., 200 mm. in most years. The rain falls in the hot months, but the degree of cloudiness is high, and so is humidity, evaporation thus being correspondingly reduced.

In the north-western deserts, near the border of the Sudan, Egypt, and Italian territory, if rain falls at all it may be expected from the same Atlantic winds that bring it to the south in the hot months. The degree of cloudiness is low, and so is humidity in these overheated deserts, and evaporation, as we have already seen at 'Uweinat, may entirely prevent the moistening of the ground by rain. These contrasts are shown in the accompanying table:

SUMMARY OF PROBABLE CLIMATIC CONDITIONS (BASED ON DATA GIVEN BY HURST AND PHILLIPS)

| *July–August.* | | *January.* | | |
|---|---|---|---|---|
| *NW. Region.* | *S. Side of Wadi Hawa. East of 24° E. long.* | *NW. Region.* | *S. Side of Wadi Hawa. East of 24° E. long.* | |
| 32° C. =90° F. | 34° C. =94° F. | 14° C. =57° F. | 18° C. =64° F. | Temperature, mean of day, uncorrected for altitude. |
| 29 | 23 | 45 | 31 | % Relative humidity, mean of day. No satisfactory figures: compare— Dakhla for NW. Region. Merowe for Wadi Hawa. |
| 0–1 | 2–3 | 0–1 | 0–1 | Cloudiness, scale 1–10. |
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South of Wadi Hawa and west of long. 24° E. the summer rainfall probably rises quickly above 100–200 mm. and humidity to about 32 per cent. summer, and 38 per cent.

*Nyima Jebels, Nuba Mountains: high level alluvial basin*

*Nyima Jebels: pool at margin of basin shown above*

*Nyima Jebels: women carrying water from high-level pool; goz plain beyond*

*Malha crater: fresh water (foreground) running from crater wall to salt lake*

winter (=per cent. relative humidity at Atbara). A. Knox, in his 'Climate of the Continent of Africa,' 1911, gives the rainfall of Tibesti as about 2 inches (50 mm.), falling in July only. He points out that the mountains are at the extreme northern limit of rainfall, even in favourable years.

*Water held on or near the surface: Rock-reservoirs and their overflow*

A considerable range of water sources may usefully be included in this group.[1] The dominant character is collection more or less *in situ*, the surplus water (if any) being in a state of flow. The reservoir may be more or less charged with rock debris, sand and gravel. Among the most important sources in the western provinces (*e.g.* the well "field" at El Obeid) are saturated pockets of rotted granite. In the Sudan, as in most of inter-tropical non-arid Africa, granite weathers commonly to a depth of 40 feet, frequently more. The residual quartz debris and clay serve as an admirable sponge for direct rainfall and local surface drainage. Masses of granite injected among impervious schists, gneisses, amphibolites, and similar hard metamorphic rocks, serve as valuable reservoirs. Geological skill is needed to locate the patches, frequently below surface accumulations of sand. The development of this source, which gives no surface indication of its presence, was in large measure the work of Mr. G. W. Grabham. It demands local rainfall for its maintenance, there is little transmission of supply.

More obvious are the cisterns (*Galt*, or *Gelta*), sometimes overflowing, that occur on the flanks and towards the base of hills projecting above the general level. Saturation of the higher rocks, and frequently of the detrital filling of hollows on their flanks, is also seen. Thus Mr. C. H. L. Skeet, then District Commissioner at Dilling,[2] Nuba Mountains, showed me this source of supply in the Mandal and Nyima Jebels in December 1932. Here the surplus water overflows down the mountain sides for a few months after the rains and saturates the sand (goz) of the plains that surround them. For a variety of good reasons the villages are situated here. As the year advances the water supply has to be followed farther and farther up the hillsides. The saturated sand at their feet, opposite the springs, maintains enormous shade trees, and elsewhere in the plains little but thorn and grass can be seen. The pools on the mountain sides are surrounded by luxuriant Palmyra palms, Euphorbia, and other southern species.

The counterpart of such a supply is seen in the peaks of 'Uweinat, in the midst of the desert. The now well-known pool of 'Ein Dua, discovered by Hassanein Bey barely ten years ago, is situated at the level of the plain that surrounds the massif. The water lies among enormous boulder-like masses of granite, which are however for the greater part *in situ* and not fallen from the upper slopes. The source of supply can only be rain which falls at rare intervals and finds its way downward through joints and cracks. It is probable that a considerable body of water is thus held in cups and pools, only the outer margin of the underground reservoir being visible. A similar supply is at times available at 'Ein Zuwaia, on the west side of the massif, but it was dry

[1] In this and the next group it is necessary to describe briefly, for purposes of comparison, some sources that are in everyday use by British residents in the Sudan: such descriptions are intended for other readers.

[2] About 70 miles SSW. of El Obeid.

in 1932. I am inclined to think that at some of the water-holes of 'Uweinat sand and gravel washed from the mountain and accumulated immediately at its foot acts as a sponge from which water may seep back into the pool. If this is so, the level of saturation of the loose material rarely ascends to a height that benefits more than the few acacias that maintain themselves at or near the water-holes. There is but little salt encrustation and grasses die a few years after rains.

Alluvial material probably plays an important part in conserving waters in Karkur Murr and at Karkur Talh. In the former there are two sources: (1) The upper pool in the gravel and sand of the wadi floor, between walls of hard siliceous sandstone, water being visible under a large boulder. It is possible that the water is thrown out as a spring along a line of unconformity in the sandstones, and that it is held in the gravel: in any case the source of supply is direct rainfall, at infrequent intervals, on the higher parts of the 'Uweinat massif. (2) The lower pools probably gain their supply from the upper by percolation along the bottom of the steep-sided wadi. The gradient of the valley is severe and a rock-step is visible above the lower pools: in 1932 the step was wet and a small quantity of water was trickling out of the boulders and sand above the step, passing over it, and seeping out of the sand and gravel not far from its foot. Thick coarse grass and young palms cover this part of the valley floor and the visible water was intensely saline. At Karkur Talh water is occasionally obtainable among huge masses of fallen rock lying among sand and gravel at the foot of a dry waterfall.[1] A large acacia (*talh*) maintains itself here and there are others farther down the valley. No water was obtainable in 1932, but the shower of 1934 has probably raised the level of saturation again. The water-hole reported by Hassanein Bey in Arkenu, a number of water-holes in Erdi and Ennedi (*e.g.* Erdi-ma Aga, Bao), in the Teiga Plateau (Umm Lehai and Teiga, described by H. C. Maydon, *Geogr. J.*, vol. 61, 1923, pp. 34–41), and at the head of the Wadi Hawa drainage basin (Umm Buru and others) may probably be placed in the class of water source described above.

The lava plateaux, such as Jebel Meidob and the Berti Hills, have their own system of water-holes governed principally by the interbedding of porous and more solid flows (*cf.* Abu Buzna, a deep cave recorded by Maydon). Caldera and craters caused by volcanic explosion illustrate the decrease of rainfall from south to north in a striking manner. In Jebel Marra,[2] west of El Fasher, craters are supplied with rain water and by springs so that they are permanently well filled. Far to the south and west they are filled almost to the rim, and the flanks may be densely covered with forest.[3] Most of the water-containing craters seem to draw their supplies partly from direct rainfall,

[1] See photograph accompanying paper by W. B. K. Shaw, *Antiquity*, 1934.

[2] See J. A. Gillan, "Jebel Marra and the Deriba Lakes," *Sudan Notes and Records*, vol. i, 1918, pp. 263–267; and H. F. C. Hobbs, "Notes on Jebel Marra, Darfur," *Geogr. J.*, vol. 52, 1918, pp. 357–363.

[3] See recent articles in the *Geographical Journal:* Noel Humphreys, "Ruwenzori: Flights and further Exploration," vol. 82, 1933, illustration opp. p. 503; M. Maclaren, "Lake Bosumtwi, Ashanti," vol. 78, 1931, pp. 270–276; also E. B. Worthington, "The Lakes of Kenya and Uganda," vol. 79, 1932, illustrations opp. p. 277; and especially E. J. Wayland, "Katwe," *Uganda Journal*, vol. i, 1934, pp. 96–106.

partly from water table, partly from deep-seated volcanic sources. Many of the crater lakes are sulphurous or saline. In Malha,[1] on the west side of Meidob, we see a crater well below the general surface containing a salt lake, while the water between Nubian sandstone and granite-and-gneiss, exposed in the crater sides, provides abundant springs, which in turn supply some water to the lake. The level of the lake is reputed to change suddenly at rare intervals, with strange noises from below. The craters between 'Uweinat and the Gilf Kebir, although some 800 metres above sea-level, are dry, and in 1932 not even the most miserable bushes survived in them. It was evident however that in the remote past all the hollow cones had held true crater lakes which breached the walls to varying depths. At the present day rare rains nourish temporarily better grass and bigger bushes in the craters than those that spring up on the surrounding plains.

*Surface, flowing, and sub-soil water*

The *fula* and the *tumud* need little introduction. The former is a pond, or a lake dammed up in the course of a river that flows perhaps for no more than a few weeks or days in a year, retaining the final part of the annual surface flow: that at El Fasher is a most important source of supply for a long period after the summer rains. The tumud is a hole dug in the floor of a watercourse after the surface flow has disappeared.[2] It taps that large body of water that percolates through the alluvial sand and gravel. The rocky floor of the wadi may be buried to considerable depth, but it may be supposed to provide a lower limit for the percolating water. As the year advances the tumud is dug deeper and deeper until it becomes impracticable as a source. The sides tend to "slump." Moreover the hole usually fills with sand and gravel when the wadi is next in spate and the process of excavation has to be repeated annually. The third type of source that one might include here is the *rahad*, a natural pool or lake (*turda*) among sand dunes, in natural hollows, or in depressions or broad lines of infrequent drainage.[3] The source of supply may be direct rainfall, filling the hollow, or run-off from neighbouring slopes; frequently, after surface run-off has ceased, springs arising in saturated rocks and superficial accumulations continue to supply the rahad. Thus the surplus water of stabilized dunes may flow into it. Many of the rahads in the northern Sudan are ponds held in red clay and black mud, which also form an impermeable layer under neighbouring stabilized dunes. How far do these sources, so common in the inhabited parts of Kordofan and Darfur, make their appearance in the northern fringes of these provinces and in the arid regions beyond?

*The tumud*

This develops in an interesting way into a permanent well,[4] which may be stone-lined by local enterprise or by official action to prevent caving of the

[1] *Cf. Geogr. J.*, vol. 81, 1933, illustration opp. p. 122; and G. V. Colchester, *Sudan Notes and Records*, vol. x, 1927, p. 233.

[2] For an interesting method of obtaining water from this source see also T. F. Chipp, *Geogr. J.*, vol. 79, 1930, p. 134.

[3] D. G. Thompson gives a valuable report on playas and the water supply of structural depressions filled with alluvial material in U.S. Geol. Survey Water-Supply Paper 578, "The Mohave Desert Region, California," 1929.

[4] *I.e.* a *sani*: see G. W. Grabham, *Geol. Mag.*, 1909, pp. 265–271, 311–318.

sides. Thus between El Fasher and Malha, after passing normal tumuds in the wadi beds, *e.g.* in the Wadi Beida near Mellit, one reaches the wells of Sayyah and Madu, situated in broad but clearly defined wadis with rocky or sandy banks. The depth of sand and gravel in the wadis is not actually known, as far as I am aware, but certainly exceeds 25 feet. These wadis, that in which Madu well is situated in particular, may not have surface flow annually at or near the sites of the wells. There is however surface run-off in the higher parts of their courses and occasionally on neighbouring rock slopes. The water so transmitted to the wadi sinks through the alluvial filling and flows through it at some depth. The rocky floor is probably covered throughout the year by water-saturated sand and gravel, and after the rains the level of saturation rises. The wells have been sunk 20 feet or more, into the saturated material. They have been stone lined, and to prevent erosion of the soft sides by ropes when water is drawn a platform is built out over the well mouth, or at least the sides are reinforced at the top by baulks of timber. Hollowed tree trunks are used as troughs for watering animals. Tumud supply is also available at El 'Ein, NE. Meidob, at a depth of about 12 feet, and Maydon (*ibid.*) got water by digging in W. Magrur. He also describes wells, abandoned and sand-filled, on the top of the sandstone plateau, but close to the Wad el Haraz, 60 miles NW. of Meidob.

As we go north however rainfall, vegetation, and herds disappear, and with them the tumud. Thus in the course of the Wadi Hawa east of 25° E., at its nearest point about 50 miles NW. of Wad el Haraz, there are at present no tumuds. In its headwaters, on the other hand, there are wells that draw water as described above from the sand and gravel. After rains graziers may dig pits in the water floor, and especially at a place like Furawiya small fields of tumuds may spring up. Sindia, in a northern tributary of Wadi Hawa, is a well of the same type, also Bueira in the main wadi.

*Tumuds and Wadi Hawa*

The wadi has been crossed at a number of places, but is still imperfectly known. Thus in recent years Hassanein Bey passed from north to south across its headwaters on his way from Ennedi to Kutum (*Geogr. J.*, vol. 64, 1924), Newbold and Shaw crossed its eastern part *en route* from Kordofan to Merga and Wadi Halfa (*Sudan Notes and Records*, vol. xi, 1928), and Newbold had been in the same district at an earlier date (*ibid.*, vol. vii, 1924). It has been visited by Sudan officials on duty, and the whole of its upper course was mapped and levelled by the Boundary Commission (Grossard, 'Mission de délimitation de l'Afrique Equatorial Française et du Soudan Anglo-Egyptien,' Paris, 1925, see especially feuille 8; and P. K. Boulnois, *Geogr. J.*, vol. 63, 1923, pp. 465–479). In 1932 we crossed it in three places, and ran for considerable distances along its course.

It is thus possible to gain a fair idea of its longitudinal and transverse sections. The following table summarizes the rate of fall from the watershed at the head of the long southern tributary which flows from Undur through Tini and Bahai Wells. Detailed levels of this country and along the Wadi Hawa to 24° E. are given in the maps accompanying Grossard's report.

*Fula, El Fasher*

*Tumud in Wadi Beida*

*Madu Well: Zayadia Arabs watering camels; Berti Hills (volcanic) on horizon*

*Thorn scrub north of Malha, near Jebel Aysa*

*Dry rahad with dead trees: between Malha and Jebel Aysa*

*Nuba Mountains: fertile valley between granite hills*

| *Place.* | *Height in metres.* | *Approx. dist. in miles from place next upstream.* | *Average fall in feet per mile.* | *Total fall in feet.* |
|---|---|---|---|---|
| Watershed (Undur district). | 950 | — | — | — |
| Near Tini Wells .. | 900 | 15 | 11 | 164 |
| Wadi floor at Camp 34, 1932. | 670 | 150 | 5 | 748 |
| Camp 46, 1932 .. | 574 | 100 | 3 | 320 |
| Newbold and Shaw's crossing. | 533 | 90 | 1½ | 133 |
| | Total .. | 355 | | 1365 |

The fall between Furawiya (in a tributary) and Camp 34 is about 800 feet in 100 miles. The approximate area drained by the wadi and its tributaries west of 24° E. is 10,500 square miles.

From its headwaters to Lat. 15° 45′ N., Long. 24° 10′ E. the valley sides are of the ancient complex of granite, gneiss, schist,[1] etc., drained by short, steep tributaries with a luxuriant growth of thorn scrub and tall grasses among which are deep nullahs and steep-sided watercourses. When in spate during the rains these drainage channels carry a great deal of sand and gravel into the main wadi. Between our two camps the ancient complex passes beneath the Nubian Sandstone, the northern side of the valley flattens out into the great plain; the southern side, on the other hand, remains fairly high. Thus between the north-east corner of Jebel Teiga and the wadi there is a drop of about 600 feet in 75 miles, and from the north end of Jebel Tageru about 575 feet in about half that distance, the country-rock throughout being Nubian Sandstone. In this sector however there is little run-off. Throughout its length there appears to be a continuous filling, of unknown thickness, of sand and gravel, and into this sinks a large part of the rain that falls directly upon it or is brought in by torrents which drain the hard rocks of the complex.

If we assume that from the headwaters to 24° E. the average rainfall is 200 mm., *i.e.* about 8 inches over about 10,500 square miles, we can assess within certain limits the amounts of water which will probably pass into the alluvial filling. East of 24° E. the rainfall is evidently sporadic and dwindles rapidly. The figures quoted above give a total of 195,148 millions of cubic feet, or about 5½ cubic kilometres. Generally a third may be assumed to be evaporated, a third to run off into rivers, and a third to be absorbed more or less where it falls. In this region however evaporation is high, so also is the run-off from hard rocks into deep channels: this means that more than the usual amount may reach the alluvial filling of the main valley, and less than a third may be locally absorbed. Probably not less than a third passes into the sand and gravel of Wadi Hawa, to which must be added any run-off from the country east of 24° E. and south of the wadi. Although these figures are speculative, we may assume, I think, that not less than 1½ cubic kilometres of water pass into the sand and gravel of the wadi floor in most years. Grossard lays special emphasis on "immense mares qui sont peu à peu absorbées par le sable" (p. 132).

It is very desirable that actual figures of rainfall, run-off and evaporation,

[1] There are a few patches of the overlying Nubian Sandstone.

and above all of thickness of sand and gravel in the wadi bed should be obtained. The filling of the wadi guides water from about 900 metres above sea-level to about 550–530 metres and brings it there in direct contact with the Nubian Sandstone on its northern bank. There is reason to suppose therefore that the southern part of the Libyan Desert gains a substantial amount of underground water from this source. Shaw has pointed out to me that similar examples of rivers conducted underground in their alluvial accumulations of earlier periods (when they flowed on the surface) are well known in the Algerian Sahara. E. F. Gautier deals with them in 'Le Sahara,' Paris, 1928, chapter 3. He describes how the Wadi Saura conducts water some 350 miles into the desert, passing under the Great Occidental Erg *en route*. Such wadis are reported to be recognizable only from the riband of vegetation that indicates their underground channels, the banks having virtually disappeared.

There are four further problems of the wadi: (1) Why are there no tumuds east of 24° E.? (2) Why is there no surface flow in that part of the wadi? (3) Why is the wadi not invaded and submerged by sand from the north? (4) How do the big trees of the wadi maintain themselves and why do they die in patches?

(1) If my figures are even approximately correct it is clear that there is much water in the alluvial filling of the valley west of 24° E.[1] and, since the wadi floor falls toward the east there is good reason to suppose that water percolates also in this direction. On the other hand, if my supposition is correct, there is considerable lateral loss (to the Nubian Sandstone) where the slope of the wadi becomes gentle. There are in fact native reports of a well in this region, but it appears to have gone out of use and its site to have been forgotten.[2] There is no proof that water is not available in tumuds here as it is farther upstream. All we can say is that the camel graziers go there in the rains and leave when the best of the ground-grazing is gone. The tree-browsing of the acacias, so attractive to camels, may be scarcely touched, and this, if exploited, should keep the nomads in the wadi almost continuously. I am inclined to think that the reason has been mainly one of security. The people are quite used to living on camel milk and can dispense with drinking water for long periods, especially when the cool weather comes. On the other hand autumn raids by the Guraan and other neighbours have been serious for a number of years, and conditions were probably far more insecure before the pacification of the Sudan in 1898 and the occupation of Darfur in 1916. In 1932 we found evidence of abundant standing pools of water almost as far east as 25° E., and I feel convinced that many of them could have been followed downward by digging as they dried. We found no people, and saw no attempt at such excavation. I believe that more settled times or a small post at Sindia would speedily lead to the reoccupation of the wadi, and that tumuds would soon appear.

(2) Why does the water not flow on the surface? The wadi surface is dry and parched when water first reaches it: a large part of the annual supply is

[1] Boulnois states that water could usually be obtained by digging about 15 feet, but the tributaries W. Tini and W. Bahai contained few points at which it was worth digging for water. His paper gives photographs of Lake Undur and Sindia Wells.

[2] Information in a letter from Mr. Anthony Arkell, Deputy Governor of Darfur.

probably absorbed immediately it enters the deposit-laden valley from the short tributaries. A large measure of the supply is thus used, gradually re-filling the sponge-like sand and silt. Shallow basins may be filled by direct rainfall, or if at lower levels than their neighbours, by percolation through the loose sand and gravel. At a later stage, when there is a genuine surplus of water, gentle overflowing of one sheet of water into the next, hindered by grasses and other vegetation, may produce such runnels as one sees. If the rain continued for another month, with heavy showers, the wadi must assuredly pass from this dying vestige of a river into something closely akin to its occasionally torrential analogues of central Darfur and Kordofan. The direct rainfall is just insufficient, and the rainfall of the watershed is swallowed up by the alluvial filling of the upper part of the wadi's course. If the grade of the valley were steeper, and if there were less sand and gravel, water might be expected to run from the upper reaches into the plain.

(3) If my explanation of the submerging of parts of the surface, without much flow, is correct, I think it is understandable that sand blown into the wadi during the preceding dry months would find a gentle angle of subaqueous repose, and that drying up would subsequently conceal most of it under fine mud. Some such process may account for the notable absence of drift sand in all but the eastern part of the wadi: it would also cause the thickness of superficial deposits in the wadi bed to increase annually.

(4) If acacias alone grew in the eastern part of the wadi there would be no need to assume the presence of considerable moisture. They survive in many remote places over the Libyan Desert, and between the Nile and the Red Sea, and seem to thrive on only occasional showers: they are at their best, perhaps, when they grow in wide shallow depressions. The luxuriant growth of a much wider range of shrubs and bushes testifies to the amount of rainfall in Wadi Hawa.[1] With the type of flow already outlined, deep-rooting trees, as well as grasses and shrubs, have the best chance of growth: the trees get the last of the water. There is every reason why the trees and shrubs should continue in a broad belt to the longitude of Bir Natrun. That some should die in patches is perhaps fairly clear: the ground of such areas usually seems to have a veneer of fine mud so perfect that it shines like water, so hard set that it is difficult to break; it may be almost air-tight. Moreover the ground below such basins may remain waterlogged for prolonged intervals, and the chances of over-concentration of vegetable acids and other solutions are considerable. In a word, I believe the trees die from drowning or poisoning, aided perhaps by the selectivity of the cells diminishing with age. We found similar patches of dead trees north of Malha, always in slight muddy hollows where one might expect them to flourish most: so indeed they do for some years, but they then probably have been killed by the water trapped round them.

In certain instances no doubt deep cracking during the dry months allows air to reach the roots of trees, and so kills them. In most of this region however

[1] For the indication of underground water by plants, see O. E. Meinzer, U.S. Geol. Survey Water-Supply Paper 577, 1927. See also Kirk Bryan, *Ecology*, vol. ix, 1928, pp. 474–478. For flora of the Libyan Desert, see W. B. K. Shaw, *Kew Bulletin* No. 7, 1934, pp. 281–289; see also Chipp's papers in *Geogr. J.*, vol. 75, 1930, pp. 123–143; and vol. 76, 1930, pp. 126–137.

the subsoil is not homogeneous enough to crack to such depth. I noticed repeatedly that the veneer of shining mud, on cracking into polygons of which the margins curve upwards and inwards, revealed loose sand without cracks. The extraordinary concentration of very flourishing trees and entirely dead trees in patches led me to the explanation given above. In such patches of dead vegetation I cannot recall seeing any that had escaped death, such as one would expect if localized cracking were responsible. According to their distribution the deep-rooted trees tended all to be dead, dying, or reasonably healthy or flourishing. For the foregoing reasons I am inclined to think that water percolates eastward, and that Bagnold's well-reasoned alternative explanation of the living and dead trees (*Geogr. J.*, vol. 82, 1933, p. 115) need not be adopted.

*The rahad*

During the rains there are considerable pools of water in the upper part of Wadi Hawa and its tributaries which merit the definition of *turda*, lake: of these Lake Undur is the largest; Boulnois reports that it dried up in May, and that thereafter digging produced no water. Along its course, as already described by Grossard (*ibid.*), pools, or rahads, lie in slight depressions for a while after rain. South of the wadi similar sheets of water, impounded among stabilized dunes or in rock-hollows, provide for the wants of flocks in increasing degree south of a line running approximately from Furawiya to Malha. Probably all of them are dry by the middle of October and tumuds take their place. Many of them are indicated between rains by flat pans of brick-red mud, surrounded by thriving acacias and other bushes which are usually a little above their level. Shrubs and grasses may grow on the pans, but are very frequently lacking. The perfection of the mud film, and, I believe, water-logging or the salinity of the water when it is drying up, seem to hinder colonization. Moreover the next rains, by filling the rahad, drown and kill the greater part of such growth except near the margins of the area covered by water. I think many published photographs of the "encroaching Sahara" illustrate this drowning process and not encroachment. I know of no true rahads north of Wadi Hawa.

*Water in sand-dunes and pans north of Wadi Hawa*

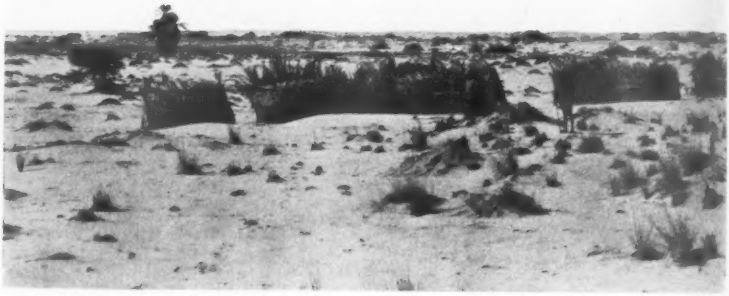
At certain points north of Wadi Hawa in the great sea of undulating, partly stabilized, sand we found patches of large acacia trees. In some instances the trees were dead and had been cut away by sand-blast, in one place a thriving "oasis" was encountered. Thus a patch of very large acacias was noticed just south of lat. 18° N. on our way from Murdi to Guroguro, and the question of their water supply arises. They were situated among rolling sand-dunes between 620 and 626 metres above sea-level: the Wadi Hawa at its nearest point is 574 metres but almost due south of the patch stands at 642 metres, and is about 80 and 100 miles distant respectively. The wadi is unlikely to have been the source of supply: if it had been similar patches, in more flourishing conditions, should have been found in increasing number in hollows as the wadi was approached. Instead, we met only the remarkable "oasis," with thriving trees, about 17 miles north of the wadi but about 60 metres above its

*Southern margin of Wadi Hawa*

*Dry wadi bed about 40 miles N. of Kutum*

*Italian troops at 'Ein Dua, 'Uweinat, 9 October 1933*

*Sarra Well: men on left running to draw water*



*Nukheila Oasis (Merga): Guraan huts at Wa'arat el Abid*

*Wadi Husein: decapitated palms, points probably used as food by fugitives from Kufara, whose refuges can be seen in the middle*

level (701 metres and 642 metres). A feature of this patch was a red mud-pan, as in a rahad, with blown sand below and stabilized dunes around it. Probably all such vegetation is kept supplied by the small amount of annual rain (less than 5 inches) and the mud-pan may serve to protect from evaporation water that falls in the hollow or percolates under it from the surrounding dunes. In none of the above is there any prospect of obtaining water at any rate till the Nubian Sandstone is reached. The conservation of rain-water in the lower parts of dunes, and its availability in hollows among them, is discussed by Dr. W. F. Hume in his 'Geology of Egypt,' vol. i, 1925, pp. 55, 78.

These observations are not without significance when we consider another line of traverse, from the north side of Wadi Hawa in about 17° N., 25° 45′ E. northward for about 60 miles, *i.e.* the district of the supposed W. Shekaya. Over a large part of this distance we found mud-pans, surrounded by old sand-dunes and occasional outcrops of sandstone, with desert plants such as tundub, hadh, sellim, growing luxuriantly. Pans and plants die out towards the north, but in many of the pans, and in the north side of Wadi Hawa, I found small shells that cannot live indefinitely without water.[1] They were not found in the acacia-patches described above, yet they occur here, appreciably nearer the outer limit of rain, and at lower levels—between 574 and 561 metres, some of the pans probably being slightly below 550 metres. For this form of life to occur only in the low regions remote from rainfall, whereas they are absent where rain is more likely, suggests to my mind a northerly transmission of ground water from Wadi Hawa.

In the arid regions to the north small mud-pans, in or near which tundub and other bushes survive for many years without water, occur on the high ground. We saw them in the plains around 'Uweinat and they were particularly noticeable on the high plateau of siliceous sandstone that we traversed between Merga and Laqiya, but all were empty and dry. If however this high ground is followed towards 'Uweinat we can readily understand the report of Bir Hamra given by Hawawir Arabs and the Bedai guide Bidi Audi quoted by Newbold (*Sudan Notes and Records*, vol. xi, 1928, footnote, p. 188). This source is located 30 miles south of 'Uweinat, *i.e.* 600–700 metres above sea-level, in "cotton soil" with water at 2 feet. Bidi's caravan watered 168 camels at it in the winter of 1915. This evidently was a substantial supply, but if we treble Bidi's estimate of distance the site would still appear to be more than 100 metres above the known water table of Merga and the adjoining oases. "Cotton soil" no doubt refers to mud-pan, which is probably indicated also in Bidi's choice of a name: hamra means red. This, at such an altitude, was certainly a surface supply, and purely temporary unless, as has been suggested, there is a very deep hollow or volcanic crater here, as at Malha.

To conclude our list of surface and shallow sources of water mention should be made of the collecting of temporary pools such as that of the "false oasis" of Jebel Hadid, in the Jef-Jef plateau between Tekro and 'Uweinat, described by Bagnold (*Geogr. J.*, vol. 82, 1933, p. 110, and illustration opp. p. 215). Here occasional showers of rain provide water which runs down opposing

[1] Major M. Connolly kindly identified these for me: *Bulinus strigosus* (Mts.), *Planorbis pfeifferi* Krs., *P. stanleyi* Smith, *Melanoides tuberculata* (Müll). These and others will be the subject of a separate report.

cliff-sides, transporting sand, gravel, and stones. Broad fans of talus are formed with a low angle of repose: the cliffs remain uncovered by debris. Blown sand is perpetually being added to the hollows between cliff-sided sectors of the plateau. Surplus run-off water lies in these depressions for a while after showers or storms and saturates the lower parts of the sand and gravel. As a source of water such pools are ephemeral, but in the example mentioned above a pool had lasted long enough for the brackish or freshwater shell, *Melanoides tuberculata*,[1] to colonize and multiply exceedingly. It is highly probable, in my opinion, that some shells bury themselves deeply in still damp sand and gravel and remain alive until the next storm fills the pool and restores them to activity. I believe also that shells survive at some depth in W. Shekaya.

*Water-table*

Among the varied sources of water supply south of Wadi Hawa the drawing of water from beneath the level of saturation of the solid rock does not occupy a prominent place. The involved structure, hardness, indifferent porosity, and local variation of the fundamental complex, and the thickness of superficial deposits upon it, have limited the use of deep wells. When Nubian Sandstone covers the complex, water may be expected above the contact, and, as already noted, springs are thrown out between the two in Malha Crater, which penetrates below the water-table. North of the Wadi Hawa the surface of the complex sinks, and is everywhere covered with Nubian Sandstone. We are thus introduced to that great hydrographic province of the Libyan Desert, the subject of Dr. John Ball's papers in this *Journal*.[2] At the time of his first paper the limits of exploration from Egypt were Sarra Well, SSW. of Kufara, and Merga, in the centre of the southern part of the desert. Hassanein Bey had accomplished his journey from the Mediterranean through Kufara, 'Uweinat, Erdi, Ennedi to Darfur, and about the same time (1927) Newbold and Shaw visited Bir Natrun (where Newbold had been in 1923), Merga and Selima. The many aneroid observations collected during the last-named journey are of the greatest value. In 1932 we completed the reconnaissance from Sarra to within sight of Tibesti and then to Tekro on the one hand, and on the other revisited Bir Natrun, Merga, Selima, and went to the Laqiya springs. The region of Nubian Sandstone between Meidob, the Wadi el Melik, and the Nile presumably forms a part of the Libyan hydrographic province, and its underground water supply remains to be studied in detail.

*The Map*

From available sources[3] I have attempted to produce a contoured map of the southern and south-western parts of the desert, coupling it first with Dr.

[1] With a few freshwater snails, *Planorbis herbini* Bgt. The relation of water to these hollows between bare cliffs may be usefully contrasted with the comparatively rich valleys of, for example, the Nuba Mountains, between scantily vegetated hills.

[2] *Geogr. J.*, vol. 70, 1927, pp. 21–38, 105–128, 209–224; and vol. 86, 1933, pp. 289–314.

[3] Mentioned in the text; especially Ball (1927), Newbold and Shaw (1928), Dr. Ball's remarks in this paper and in Hassanein Bey's (1924), Grossard, the French maps 1/M (1927) and 1/5M (1931), War Office G.S.G.S. 2871 1/2M (1928), Beadnell (1931), and P. A. Clayton, *Geogr. J.*, vol. 81, 1933.

Ball's map, and, after its completion, with the 1/M sheets newly published by the Survey of Egypt. Altitudes based on the 1932 journey are derived from Shaw's observations with interpolated inter-camp readings of my own, correlated with Shaw's three times a day. Upon this I have superimposed the outcrops of the ancient complex as mapped in 1932. Mr. G. W. Grabham has given me details of the exposures in northern Darfur, Kordofan, and Dongola. With the exception of the volcanic rocks, the whole of the rest of the territory is known or presumed to be made of sandstone. The sandstones of 'Uweinat, Erdi, Ennedi include Palaeozoic as well as Nubian (Cretaceous) rocks, but it is not clear that the variations of dip and strike among them affect the flow of water. The rocks of the ancient complex, although they may not affect static level, certainly are for the most part poor water-bearing and water-transmitting rocks.[1] It is clear from the map that a ridge of sandstones runs from 'Uweinat towards Erdi, and, in terms of topography, we may speak of the Sarra corridor, which connects Kufara with the Chad Basin *via* Tekro—a most important physiographical factor. On the east side of the 'Uweinat–Erdi–Ennedi ridge is the basin-shaped southern end of the sandstone outcrop, which, farther north, dips under younger sediments and supplies Kharga and Dakhla with artesian water. I think we must keep these two units clear in our minds when we consider problems of water supply.

*Determinations of water-level*

The following figures have become available in recent years:

(1) *Sarra corridor between Chad Basin, Kufara, and the north*

Col. Tilho's paper in this *Journal* provides much valuable information (vol. 61, 1920, pp. 81 *et seqq.*), and a recent official French map gives a number of levels, of which the northernmost are quoted here. The height of Tekro is given as 420 metres, whereas our determination in 1932 was 448 (see Afrique nord. est, feuille No. 2, Service Géographique de l'Armée, Paris, 1931, 1 : 5,000,000). The height of the water at Sarra is still open to question. Prince Kemal el Din stated that it was reputed to vary within 20 metres, and gave the figures 390–411 metres. In 1932 the water was 195 feet from the surface of the well and we determined the ground-level to be 1723 feet, 525 metres above sea-level, and the water therefore at 466 metres. This is a major discrepancy that remains to be cleared up. In the following list the figures in brackets are alternative determinations discussed above. With the exception of Sarra and Bishara, the sources are natural pools or lakes with expanses of salt, the water in many being more or less sulphurous (as at Sarra), in some, as at Tekro, a foot or so of sand or salty "pan" covers the whole area. Well-sites near the hills which may be supplied by superficial run-off are omitted. Bogar, at the western end of the Murdi Depression, is included provisionally.

[1] For geology see Abstracts of Proceedings of the Geological Society of London for 27 June 1934. For outcrops of the ancient complex remote from route of 1932 see 1/2M Geological Map of Egypt, 1928; H. J. L. Beadnell, *Geogr. J.*, vol. 77, 1931; Denaeyer, in 'Atlas des Colonies françaises,' 1932. I am very much indebted to Mr. G. W. Grabham for tracings of the outcrops in the Sudan which he had made for me. For some indications of distribution of sand dunes, etc., see map in *Geogr. J.*, vol. 82, 1933.

The altitudes of some salt-pans which yield water, and from which salt is dug, are lacking.

| | *Metres.* |
|---|---|
| Kuruadi .. .. .. .. .. .. | 185 |
| Kishikishi .. .. .. .. .. .. | 205 |
| 'Ein Galaka .. .. .. .. .. .. | 215 |
| Faya .. .. .. .. .. .. .. | 215 |
| Bokalia .. .. .. .. .. .. | 255 |
| Yarda .. .. .. .. .. .. .. | 275 |
| Kurudi .. .. .. .. .. .. | 294 |
| Unianga Kebir .. .. .. .. .. | 345 |
| Unianga Serir (? Saghir) .. .. .. .. | 360 |
| Madadi .. .. .. .. .. .. | 365 |
| Umm el Adam .. .. .. .. .. | 380 |
| Guro .. .. .. .. .. .. .. | 395 |
| Jikjik .. .. .. .. .. .. .. | 410 |
| Tekro (420) .. .. .. .. .. .. | 448 |
| Bogar (Murdi) .. .. .. .. .. | 495 |
| Sarra (390–411) .. .. .. .. .. | 466 |
| Bishara [1] .. .. .. .. .. .. | 432 |
| Kufara (Awadel) .. .. .. .. .. | 434 |
| Kufara (Ezeila) .. .. .. .. .. | 389 |

I am inclined to think that Sarra is virtually at the highest point attained in this region by the Libyan Desert water table. Dr. Ball has expressed the opinion (*Geogr. J.*, vol. 70, 1927, pp. 110–117) that the water may be percolating water from a more or less local rainfall, conveyed by higher-lying permeable strata than those which contain the supplies of Kufara and of the Egyptian oases. He suggested that, as the static level should lie here at about 500 metres, a better and more stable, even overflowing artesian, source of water might be tapped by deepening the well. But a reconnaissance westward has shown that Sarra lies on the NE. side of an anticlinal or dome-structure, and that the beds fall away in dip and altitude towards Tibesti and Tekro. It is therefore unlikely that the water table rises to 500 metres in this region. It seems that Sarra, with its warm and sulphurous water, and Tekro belong to the northern Lake Chad province, so far as water table is concerned, and that the former is on the boundaries of this and of the Kufara–Libyan Desert province. On the map therefore I have ventured to show these relations by contours of static water-level. The line Tekro–Sarra–Bishara–Kufara suggests that the 500-metre static water contour bends sharply round the north-west flank of the Erdi–'Uweinat high ground.

(2) *Southern Libyan Area*

The following records for Bir Natrun (El Atrun), Merga, Laqiya, Selima, are quoted by Bagnold (*Geogr. J.*, vol. 82, 1933, p. 228), most of them derived from Dr. Ball's work, from Dr. Ball's computations of Newbold and

[1] Bruneau de Laborie gives the depth of this hand-cut well in solid rock as 110 feet: see *Illustrated London News*, 5 April 1924, p. 579. The surface-level is given as 446 metres on the 1931 French map quoted above.

Shaw's readings, and from the journeys of 1930 and 1932. I have converted his figures in feet to the nearest metre, and have added the altitude of water in Wadi Husein, near Merga, of the Akasha (Ukma) spring in the Nile valley, and some levels given by Ball (1927) and Beadnell in *Geogr. J.*, vol. 77, 1931, pp. 245–250, as amended on 1/M International sheet 1934. The figures without brackets are deemed to be the most accurate where alternatives are available.

| | *Metres.* |
|---|---|
| Bir Natrun (El Atrun) | |
| Bir Milani [1] | 521 |
| Bir Natrun [1] | 494 |
| Bir Sultan | 504 |
| Merga (Nukheila) (498–504) | 509 |
| Wadi Hussein | 497 |
| Laqiya el Arba'in | 346 |
| Laqiya 'Umran (333) | 324 |
| Selima (246–261) | 246 |
| Bir Misaha (hand-dug well) | 250 |
| Bir Sahra (hand-dug well) | 242 |
| Bir Terfawi | 240 |
| Bir Safsaf | 230 |
| El Sheb | 215 |
| Bir Abu Husein | 174 |
| Bir Kiseiba | 166 |
| Bir Murr | 154 |
| Akasha (Ukma) springs [2] | 172 |
| Dakka | 99 |

From the new data thus available I have been enabled (with Dr. Ball's full concurrence) to make slight amendments to the courses of the more southerly portions of some of the static underground water contours shown on his map of 1927, and also to prolong them southward in the Sudan and to supplement them by additional static contours in the northern part of the Chad basin. The proximity of his estimated levels to those actually measured subsequent to the publication of his paper are sufficient indication of the accuracy of his forecasting. Dr. Ball's results also seem to answer in the negative the question of the Nile supplying water to the Libyan Desert: the contours rise towards Ennedi and in particular towards the southern end of that watershed, where, significantly enough, Wadi Hawa is situated. The level of the Nile coincides with that of Bir Natrun and Merga south of Rejaf on the White Nile and south of Roseires on the Blue Nile, near the Uganda and Abyssinian borders respectively: the altitudes of Laqiya and Selima are met on the Nile near the Fifth and Fourth Cataracts respectively.[3] The springs of Ukma (Akasha) might be

[1] Actual levels of water surface, the readings were taken 6 feet above water, for which allowance is here made.

[2] Lepsius stated that the springs were about half-way between low-Nile and the bank. I have accordingly assumed them to be about 4 metres above the level of low-Nile at Akasha.

[3] These remarks do not refer to water in the Wadi el Qa'ab, near Dongola, a depression below the level of the immediately adjacent Nile. See also Dr. Ball's figure in *Geogr. J.*, vol. 70, 1927, p. 31.

deemed to be Nile water absorbed by the Nubian Sandstone and returned to it at this point, but their warm and sulphurous nature (as at Sarra Well) are by no means accounted for by such a supposition. On the other hand Dr. Hume ('Geology of Egypt,' vol. i, 1925, p. 140) notes that the level of the warm spring of 'Ein el Sira near Cairo varies with the height of the Nile.

Dr. Ball indicated the Erdi–Ennedi highlands as the origin of the artesian water of the Libyan Desert and, if my observations on Wadi Hawa and its vicinity are correct, we might conclude that Ennedi and the boundaries of Western Darfur are the most important sources of origin. Every geological advantage for conducting water into the permeable sandstone of the SW. Libyan Desert seems to be present. In Ennedi and Erdi the Palaeozoic sandstones are horizontal or inclined gently in N.–S. direction: the Nubian Sandstone which lies on their eastern flank has according to my observations a slight but distinct easterly dip, and the ground falls steadily with it from the hills to Bir Natrun–Merga.

In the Wadi Hawa basin the ancient complex tends to concentrate run-off into the wadi, the alluvial filling of its bed to conduct it to the broad regions east of 24° E., and to place it in direct contact with the Nubian Sandstone which there flanks the wadi. By these means water is conducted from high southern regions of distinctly heavy rains to the permeable beds of the arid plains. The situations of the oases themselves are directly related to the incidence of wind erosion upon the varied rocks of the Nubian Sandstone, influenced also by structure, dip, and strike. The Bir Natrun water-holes lie at the foot of a N.–S. scarp, which stretches in the direction of Merga. As we approached the former from the west we were ascending a well-defined succession of Nubian Sandstone strata dipping E.–SE. Both at Bir Natrun and Merga soft sandstones in the series have been deeply eroded by wind, causing scarps to form, and to recede: the soft beds have thus been revealed at greater depth down the slight dip-slope. Many miles of the more resistant bed below the weak member form a featureless plain west of the oases. There is no sign that Merga–Natrun mark either anticline, syncline, or fault. Between Merga and Laqiya the Nubian Sandstone dips slightly E.–SSE. or is slightly undulating, few striking features occurring till small anticlinal crests, broken by denudation, make their appearance about 30 miles south-west of Laqiya el Arba'in, increasing in frequency till the Laqiya water-holes are reached, situated between rolls or anticlinal flexures.

Laqiya 'Umran is entered from the ESE. by a defile between high sandstone cliffs, which open out unexpectedly to reveal the water-hole in the middle of a broad depression. The route of entry lies in fact along the crest of an anticlinal roll with E.–W. or ESE.–WNW. strike: the water is in the centre where the core has been laid bare by denudation. Dips suggest that the structure is pitching slightly to the ESE. revealing lower beds in the series as one goes westward. 'Umran is thus situated near the foot of the scarp formed by the "raw edged" east end of the roll. As we go westward we cross the broad flank of an associated undulation or roll with trend about NW.–SE. Accordingly the cliffs fall back into a broad bay, stretching northward almost at right angles to the 'Umran depression. Again the water is found near the point at which the water-bearing bed emerges from the foot of the scarp.

The overlying beds can be traced in the scarps from one well to the other, and the opposed undulations traced. At the point at which the strike changes from about ESE.–WNW. to about SE.–NW. the north scarp is at its lowest, is least tilted, and least broken. This is almost midway between the two wells and affords a poor route for cars: the only alternative routes seem to me to make a wide detour round the whole of the folded structures, since the scarps are precipitous. The Laqiya wells, with their superficial deposits around them, seem to show that locally the water table is modified by structure, by the degree of folding of the optimum water-bearing strata (with associated impermeable beds). Midway between Laqiya and Selima northerly dips predominate. Selima again introduces marked dips, deep erosion of soft members of a tilted series, scarp formation, and revelation of water at the foot of the scarp. Scouring elsewhere in the vicinity must have approached so close to water-level that shallow boring would almost certainly produce water if required. North and north-east of Selima the inclinations of the beds, though gentle, suggest the presence of broad anticlinal flexures with axes running about ENE.–WSW. or almost E.–W.

It emerges that all the oases of the southern Libyan Desert, north of Wadi Hawa, are intimately connected with disturbance of the horizontality of the Nubian Sandstone, and that water-level is reached in such areas by differential erosion of (*a*) anticlinal rolls, (*b*) soft members of a dipping series of beds. Faulting appears to play no part here, though it enters into the scheme of things in Kharga. The wide differences of level in the Bir Milani–Bir Natrun–Bir Sultan group is, I think, explained by Dr. Ball's conclusion (appendix to Newbold and Shaw's paper, *Sudan Notes and Records*, vol. xi, 1928) that the highest recorded level is the most accurate. In other words, two of the wells and their salt-pans are considerably below the top of the water table. Interdigitation of white sandstones and white shales and clays (virtually impermeable) which I noticed in 1932 in the Nubian Sandstone in this locality, and northward to Merga, tends to split the water-bearing beds into upper and lower layers.

To conclude: while I do not propose to enter the lists of the Zerzura discussion, I think we can reasonably make the following deductions:

(1) In the south-west the country of the so-called Wadi Shekaya, especially near Wadi Hawa, would, I am confident, yield water at slight depth, and after rain an additional supply, held up in the sand and pans, might be expected. I think traditions of water in this district are founded on fact.

(2) This line of probably fruitful ground may be continued northward of Merga on its west side. Reports of water here, *e.g.* by Newbold, in *Sudan Notes and Records*, vol. xi, 1928, pp. 187–189, gained from Hawawir Arabs and from the guide Bidi Audi, may well be correct.[1] Probably the water-holes, whether now open or sanded up, were, or are, tapping the water table. The only travellers who have passed this ground in the critical part are Prince Kemal el Din and Dr. Ball. The results were by no means finally negative.

[1] *I.e.* Bir Bidi, found by Bidi Audi (sometimes called Wad Awad) in 1904, not to be confused with his Bir Hamra or with the well found in 1931, 5 miles west of Jebel Kashafa, Bir Natrun; see Newbold, *Geogr. J.*, vol. 72, 1928, p. 551, and Anthony Arkell, *Sudan Notes and Records*, vol. v., 1922, p. 133.

Much of the country adjacent to 26° E. between 17° N. and 20° N. lies at about 560 metres, so far as we yet know, and, according to my estimate, is as low as 550 metres in Wadi Shekaya. Static water-level is evidently at 500 metres between Wadi Hussein and Merga, but is as high as 521 metres at Bir Milani. As the static level is rising steadily westward there is good reason to suppose that the difference in altitude between surface and static water contours is very small in Wadi Shekaya. If moreover water is passing northward in this locality from the Wadi Hawa, as I believe it to be, the water table is likely to be yet nearer the surface. Therefore I think it is improbable that available water is more than 90 feet below the surface and probable that it is within easy digging distance—perhaps 20 feet or less in hollows. The mysterious well of Teigo may represent its appearance at surface. With the present knowledge of both types of contour the hunt for lost oases can be narrowed to certain predicted areas.

(3) Geological structure may be responsible for the flow of true water-holes, as in Laqiya and Selima, in certain circumscribed districts not yet thoroughly searched. In my opinion a search of the country west and south-west of Laqiya and south of Selima might yet produce other natural sources. Farther afield, the Nubian Sandstone east of Tibesti may contain such springs on or very near the surface, and there is hearsay evidence to that effect.

*Summary of Sources of Water*

The following summary may be useful. Storage of water in tanks and other purely artificial means such as the filling of hollowed tebeldi (baobab) trees with water are omitted: such methods are employed in the more densely populated areas between El Obeid, El Fasher, and the Bahr el 'Arab.

| | *Country south of Wadi Hawa.* | *Southern Libyan Desert.* |
|---|---|---|
| 1. | Surface flow of khors and wadis, torrential during rains, gradually subsiding to tumuds. | See discussion of Wadi Hawa: otherwise occurs only after rare storms. |
| 2. | Rock pools, especially in Granite and Gneiss country and volcanic hills. | Occur in the hills of the continental watershed. |
| 3. | Rock pools with superficial deposits as reservoirs. | As above. |
| 4. | Wells sunk in rotted granite, etc. | — |
| 5. | Springs flowing into volcanic craters. | — |
| 6. | Fulas (artificial). | — |
| 7. | Tumuds, also lined wells. | See 1, above. |
| 8. | Rahads in goz (stabilized dunes) or in hollows of superficial deposits. | Pans among dunes, water rarely available: rare temporary pools in broken country. |
| 9. | Pools and rahads on slightly permeable rocks. | Ephemeral. |
| 10. | (?) | Rainwater held up in superficial deposits above subjacent water-table (pools after rains). |
| 11. | Springs supplied by underground water. | Surface of ground below static water-level, oases. |

| | | |
|---|---|---|
| 12. | Feasible in extensive areas of Nubian Sandstone, special difficulties in Granite and Gneiss country. Shallow wells locally draw water from lower part of stabilized dunes where resting on impermeable platform. | Digging of wells to underground water-level. |

I wish to record my indebtedness and sincere thanks to Dr. John Ball for reading a draft and the typescript of this paper, for criticizing it in detail and giving me much valuable advice, and to Mr. G. W. Grabham for making much of the work possible and for enabling me to see some of the sources under his guidance in the field.

*Postscript.*—Mr. C. G. T. Morison has recently observed in the Bahr el 'Arab and neighbouring regions that acacias cannot live in the hollows filled with black cotton soil. The ample rains cause the hollows to be waterlogged annually for considerable periods, and only grasses grow in them. Acacias flourish on the neighbouring sandy slopes and rocky ground. Far from the dead trees of Wadi Hawa and of the red pans and rahads indicating an encroachment of desert, it is clear that they show, as I have suggested, that there is locally *too much* surface water.

# THE DOMESDAY GEOGRAPHY OF NORFOLK AND SUFFOLK: *A paper read at the Afternoon Meeting of the Society on 14 January 1935, by*

H. C. DARBY

PROMINENT in the physical geography of Norfolk and Suffolk has been the chalk escarpment that lies in the west of the two counties, along the border of the fenland. This escarpment forms a belt of open downland country, for the most part, over 200 feet above sea-level, but completely broken towards the middle by a gap, which isolates the Norfolk Heights rising to 300 feet from those of Suffolk which reach 400 feet. The main watershed of East Anglia naturally lay along these elevations. On the westward slope, the Nar, the Wissey, the Little Ouse, and the Lark, flowed into the Fenland. To the east, the longer courses of the Bure, the Wensum, the Yare, the Waveney, the Gipping, and the Stour reached the North Sea. The events of the Quaternary Glaciation considerably modified the detail of this drainage system and, in particular, the morainic Cromer Ridge was left to form a secondary watershed in the north. Finally, post glacial submergence produced the marshes and the drowned valleys, both in the east and in the west. Indeed, the glacial epoch had been of supreme importance to East Anglian geography. As a result, the eastern portion of the chalk outcrop became covered by the boulder clay that had been deposited upon the central areas of both counties. Derived in all probability from a Lincolnshire ice-sheet, this clay was distinctly chalky in character, and was not as tenacious as the clays of the Weald and the London Basin. And on ecological grounds it is probable that this clay furnishes the major clue to the original distribution of woodland. "There can be little doubt," writes Tansley (1), "that practically the whole of the clays and loam were at one time covered with oak forest."

These facts, then, sum up the physical geography of the area during the Anglo-Saxon and Danish periods: low relief intersected by numerous rivers; and a wooded interior bordered on east and west by the marshy tracts of Broadland and Fenland respectively.

The purpose of this paper is to construct a picture of the economic geography of this terrain at the close of these periods, using the Domesday Survey alone as a source-book, partly because it is substantially the only source, and partly because this paper is an experiment in the use of Domesday statistics. And I am indebted to Mr. John Saltmarsh, of King's College at Cambridge, for discussing many Domesday problems with me.

## *The Settlement of Anglo-Saxons and Scandinavians*

The earlier stages of the Anglo-Saxon settlement are, presumably, marked by "hams" and "tons" and other place-names; a further stage in settlement may be registered by those place-names, moderately numerous, that terminate in *ley* or *den*, or those other place-names that contain some *wood* element. Such names are frequent on the clay lands, and each of them represents pioneering effort and reclamation from primitive woodland. Moreover, both in Norfolk and in Suffolk, there are many clusters of two or more vills bearing

the same name, in a way that may indicate village colonization and the throwing off of settlers from a parent centre (2); the Burnham, the South Elmham, and the Ilketshall groups are particularly outstanding. But all too frequently such hints, covered up by the changes of later time, are open to dispute, and refuse to yield up their meaning. Sometimes we can only wonder whether they had any meaning at all!

Most fascinating among such problems is the structure of the villages themselves. In the adjoining county of Cambridge distinction has been made between the nucleated villages of the open country, representing primary settlement in clusters, and the dispersed villages of the wooded areas representing the subsequent colonization of outlying parts (3). But in Norfolk and Suffolk the dispersed village seems ubiquitous in its distribution, which cannot be thus explained in terms of woodland alone. Nor does the Domesday Book itself give any help in this direction; there, the term "berewick," it is true, is used very frequently to denote an outlying portion of a manor, but its significance in East Anglia, at any rate, seems to be administrative rather than geographical. In other ways, too, it is dangerous to read into the bare facts of the Domesday record any picture of dispersed villages struggling to subdue the woodland around. The Suffolk village of Bradley is a case in point. The modern map shows the larger cluster of Great and Little Bradley surrounded by satellite hamlets. The place-name itself and the presence of wood are also suggestive. The Little Domesday transcripts, when assembled from their different folios,[1] read thus:

Folio 371b: In Bradley 8 freemen (held) 80 acres and 1 bordar. And 2 ploughs. And 1 acre of meadow. And they were worth 11*s.* and 3*d.*

In the same (vill) 4 freemen (held) 60 acres and 1 bordar and 2 ploughs, and 1 acre of meadow. Worth 10*s.* Saint Edmund (has) commendation and soke and sac.

Folio 396b: In Bradley were then as now 2 freemen with 69 acres. And 1 acre of meadow. Then as now 1 plough. Worth 17*s.* and 6*d.*

Folio 397a: In Bradley (are) 4 freemen, Ulwin, Leuric and Lavin, and they have 15 acres. The fourth is Bundo and he has one carucate of land. Then as now 2 ploughs. And 2 acres of meadow. Worth 22*s.* and 6*d.* Of these Richard's predecessor had not commendation T.R.E. Saint Edmund had the entire soke.

Folio 429a: (In) Bradley Olf the thegn held as a manor T.R.E., now Roger holds in demesne, 7 carucates of land. Then as now 14 villeins, and 12 bordars, and 6 serfs. And 3 ploughs on the demesne. And 7 ploughs belonging to the men. And 13 acres of meadow. Wood for 500 swine. Then as now 1 rouncey. Then 12 beasts, now 18. Then 60 swine, now 53. Then 20 sheep, now 63. And 7 goats. And 1 hive of bees. A church with 15 acres of free land. Then worth 6 *li.*, now 5 *li.* It is 1 league long, and 7 furlongs broad. And (pays) 6*d.* in geld.

Bradley thus consisted of one large group of villein and servile holdings, with four lesser groups of freemen; but it must be said at once that these tenurial arrangements *per se* cannot, in any way, be collated with the pattern of the settlement. Considered in relation to the other evidence they may possibly be suggestive here—that is all. Too often, alas, any Domesday paper must consist of conjectures and uncertainties.

[1] The land-holders were: the Abbot of St. Edmunds (folio 371b); Richard, son of Count Gilbert (folios 396b and 397a); and Robert de Todeni (folio 429a).

Long before the Anglo-Saxons had completed their work of colonization there came a second Nordic invasion. It was in Norfolk that the Scandinavian element was strongest, and there is one district particularly well characterized by Scandinavian place-names that denote primary settlement (4). It lies around the estuaries of the Bure, the Yare, and the Waveney, chiefly in Norfolk, but extending somewhat into the adjoining Suffolk hundreds. More than one half the total number of place-names in the hundreds of East and West Flegg are Scandinavian, and the predominating termination is *by*, meaning village or homestead. It may also be significant that this is the area where the Domesday entries show a remarkably high percentage of freeholders. In the remainder of the two counties, particularly in Suffolk, Scandinavian names are scarce; and, where they do occur, they rarely end in *by*, but quite frequently in *thorpe*, which implied a hamlet or daughter-settlement. In some cases *thorpe* stands alone; in others it is named from an adjacent village. Burnham, Saxlingham, Shouldham, in Norfolk, and Ixworth in Suffolk, were, probably, earlier settlements than their respective thorpes. There are to-day Thorpe Farms in West Wretham and West Harling. Shipdam and Hundersby too have a Thorpe Row and a Thorpe Street respectively; while the hamlet of Barrow is called Burthorpe; further, many of the Domesday "thorpes" have since disappeared as separate vills.[1] Continued clearing is also suggested by *thwaite* elements (seven in Norfolk and two in Suffolk) which indicated reclaimed land. The medieval records are full of many other Scandinavian names which have now disappeared; this is particularly true in the case of field names and personal names in the feet of fines (5) which, it should be noted, suggest considerable Scandinavian admixture throughout the entire region. It is not surprising therefore to find that many of the berewicks of the Little Domesday bear Scandinavian names. In some manors with double berewicks, one was Scandinavian and the other was not. In Fakenham both were Scandinavian and, of them, the record stated:

> "To this manor belongs 1 outlying estate called Alatorp (Alethorpe) consisting of 1 ploughland; then as now there were 3 bordars and 1 serf and on the demesne 1 plough and 2 oxen belonging to the men and 2 acres of meadow; and another outlying estate called Torpaland (Thorpland) consisting of 1 ploughland and 1 plough and 1 serf."

Such colonization was the contribution of the Scandinavians to the development of the village community in East Anglia. Some of the invaders may have settled in scattered homesteads as they had been accustomed to do in their homeland (6) and their presence may help to explain, even if it does not solve, the widespread distribution of the dispersed village in Norfolk and Suffolk.

### *Domesday Statistics*

The outcome of the Gloucester Gemot at the end of 1085 was the sending out of officials to collect from each shire, hundred, and vill the information now

[1] Some examples are: Baconsthorpe in Attleborough, Glosthorpe in Bawsey, Ramthorpe in Newton Flotman, Akethorp in Lowestoft, Fotestorp (Fodderstone) in Shouldham Thorpe. Blomefield, in the 'History of Norfolk' (1805), places Idikethorpe in Wymondham (ii, 499); and Toketorp in Norwich (iv, 453).

At this time, too, there were three Wrethams, all berewicks to Necton; see Blomefield, i, 471.

preserved in the two manuscript volumes which, within a century of their compilation, had become known as the Domesday Book. The larger of the two volumes deals with the greater part of England; the smaller deals only with the counties of Norfolk, Suffolk, and Essex. Although so important in matters legal and economic, their contribution to a reconstruction of the contemporary geography has not yet been fully extracted. And in this connection East Anglia is particularly fortunate because the details contained in the 'Little Domesday' are much fuller than those given in the larger volume.

Three general points have to be noted about these details:

(1) The plan adopted by those who compiled the present books from the original returns is only in part geographical; while each county is dealt with separately, the information is arranged within each county, not on the basis of hundreds and vills, but under the heading of the tenants-in-chief. And as the possessions of tenants were scattered about in various hundreds, the data relating to each vill have to be assembled from different pages.

(2) "One great purpose," wrote Maitland, "seems to mould both its form and its substance; it is a geld book," primarily intended for assessment purposes. Naturally this has some bearing upon its contents. Topographical information is thus nothing more than a by-product, and in many ways it is very meagre and full of surprising lapses. Indeed, when an item is recorded for any vill we cannot always assume that it was geographically within the boundaries of that vill; all we can say is that the vill was responsible for this particular set of profits.

(3) Most of the entries state what the land was worth at the death of Edward the Confessor in 1066, what it was worth when its existing owner received it, and its value when the returns were compiled. For each manor, there was given the number of villeins, cottars, and other workers; the number of ploughlands and oxen; the assessment to the geld; and particulars about churches, mills, and fisheries, together with other miscellaneous information. This is the raw material out of which the contemporary geography can be reconstructed.

*Regional Prosperity*

The first point that emerges is that, apparently, by the time of the Domesday Inquest, Norfolk and Suffolk were the two most densely peopled counties in England. Data, computed from the estimates of Ellis (7), show that this density was twice that of some southern counties and many times that of the Northern and Western counties. Many reservations have to be made in interpreting these statistics, and I hope to discuss them more fully later, but their general import seems tolerably clear.

The intensity of settlement was not uniform, and the distribution of the Domesday vills in the two counties reveals regional differences about which there have been many misstatements (Fig. 1). It has been asserted, for example, that the loam area around Aylsham and Walsham was open country, easily settled, and where consequently villages were most numerous; and further, that upon the central boulder-clay areas vills, although frequent, were only moderately numerous. This may have been true for the earlier Saxon period (though it is an inference and not a fact), but the map of Domesday vills shows those on the wooded boulder clay south-east of Norwich to be at

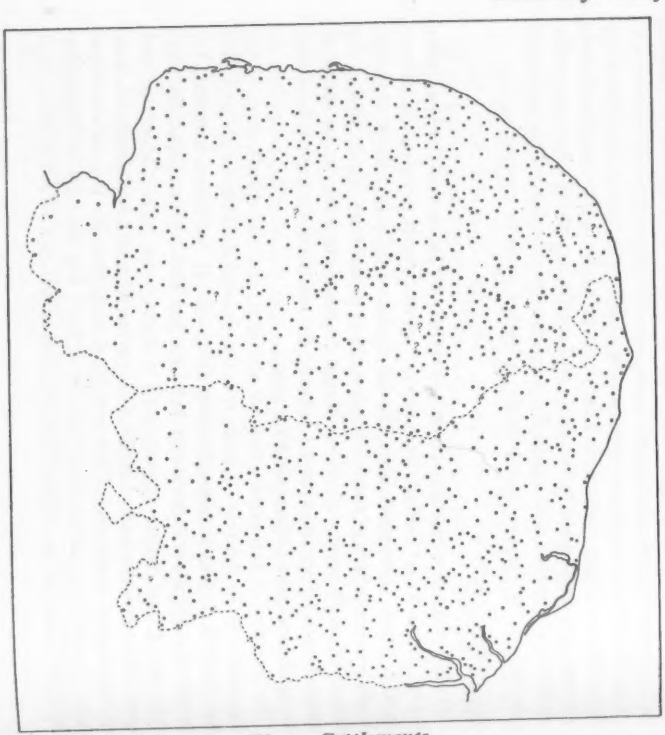


*Fig 1. Settlements*

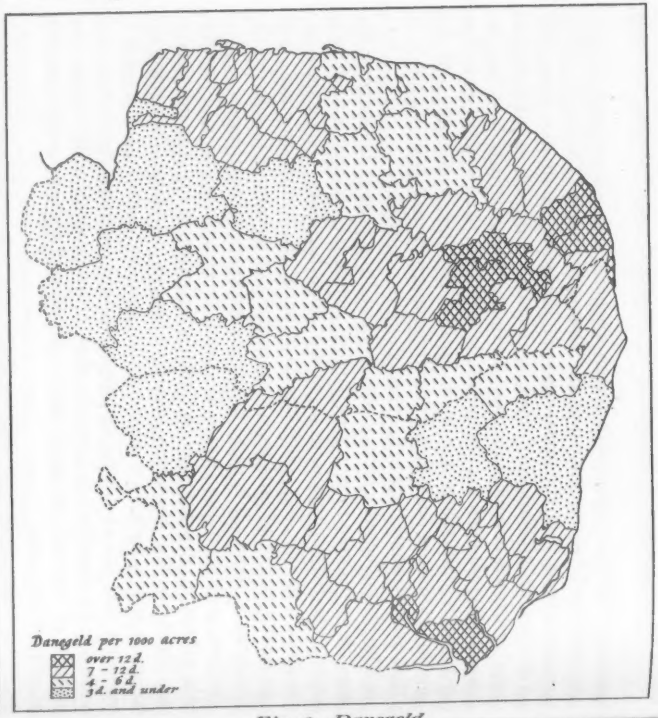



*Fig. 2. Danegeld*

least as densely clustered as those of the loam district. That fact speaks for itself. The only generalizations to be drawn are these: that in the west of both counties, upon Breckland and Fenland, villages become scarce; and that the wooded clay areas influenced not so much the frequency as the occupations of their villages. Indeed, in the north-west of Norfolk, where boulder-clay was interspersed with sand and gravel, and where the woodland was, probably, most open, the villages are relatively less dense. In any paper dealing with Domesday conditions it is as well to stress such anomalies and to abandon easy generalization.

What light do the Domesday statistics themselves throw upon the distribution of settlement and regional fertility? Three sets of data provide some clue; and, on the accompanying maps, each is plotted out per thousand acres for each hundred:

(1) The incidence of the geld-assessment. If we were quite sure to what extent this reflected the relative prosperity of different regions in the middle of the eleventh century, it would be most illuminating. But some estates were exempt from the geld, some were over-rated, some were under-rated; and the very method of the survey seems to be the result of the fact that the geld assessment did not correspond to the actual features of existing land-settlement. And, in any case, the method of assessment in Norfolk and Suffolk was peculiar (8). But, whatever the circumstances, it must have contained some fragments of the truth; and Fig. 2 provides at least some ratios for the purpose of comparing the different hundreds of the two counties.

(2) The recorded population (Fig. 3). But the survey was not intended to provide a census. There must have been many people who, for various reasons, were not mentioned; and, on the other hand, some people were recorded more than once in different connections. Such imperfections were however common to all the entries, and we can assume that, as far as agricultural population was concerned, these figures give a clue to the relative importance of the different hundreds. And these ratios need not involve us in any discussion about the total population.

(3) The distribution of plough-teams. These indicate more directly the main agrarian facts for the three dates *tunc*, *post*, *modo*. If the existing teams were fewer than those of past time, the entry sometimes adds that a number of teams could be "restored"; of Rougham, in Norfolk, it is said: "then 3 ploughs on the demesne, afterwards and now, none; and 4 could be restored (*restaurari*)." Or, again, for Flockthorpe (now in Hardingham) the entry is: "then 3 ploughs on the demesne, afterwards and now 2, and 1 could be restored." And that "x ploughs could be (*fieri*)" is a familiar entry. The number of plough-teams in some of the Central Suffolk hundreds had been considerably reduced between 1066 and 1086. But, apart from throwing light on colonizing aims in 1086, the totals for each hundred must reflect the distribution of land under cultivation. Fig 4 has been constructed on that assumption.

The three sets of data present varying degrees of uncertainty but, if they cannot be trusted for minute accuracy of detail, they are useful enough for the purposes of broad generalization. When the three maps are compared, certain common features stand out clearly enough: the great prosperity of the

Fig. 2. Domesday

Fig. 1. Settlements

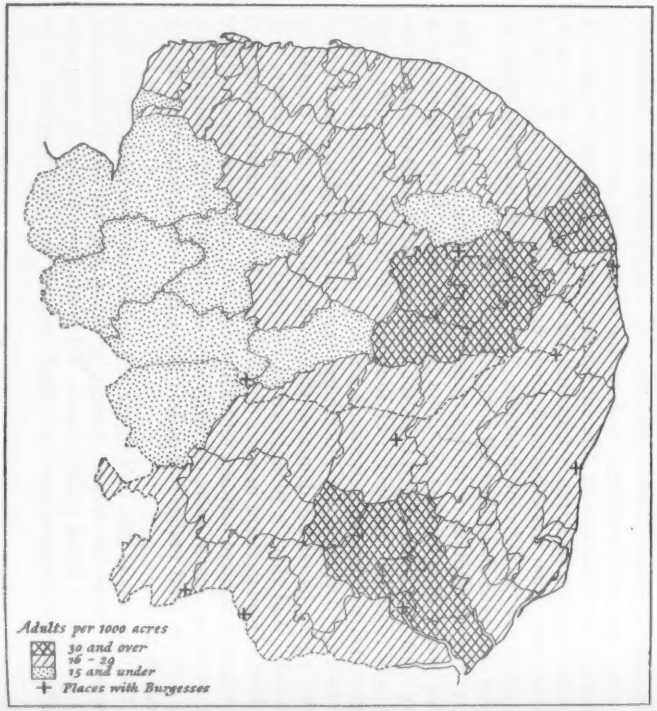



Fig. 3. Recorded adults in 1086

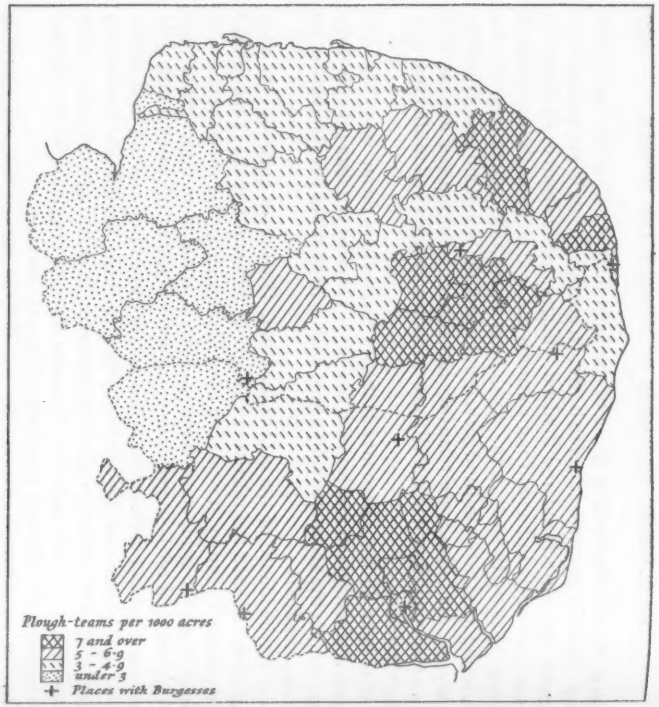



Fig. 4. Plough-teams in 1066

area south and east of Norwich and of some of the Central Suffolk hundreds; the poverty of some of the westernmost portions of the two counties; and the moderate prosperity of the rest of the area, particularly of Suffolk. These facts, at any rate, rise above the uncertainty of the evidence; with them we must be content.

*The Distribution of Woodland*

The Domesday Book, in general, recorded information about woodland in a variety of ways. A very frequent formula was: "there is a wood x leagues by y leagues"; sometimes the estimate was given in the form of acres, in hides, or hedges. Such terms were used in the Norfolk hundred of Clacklose, for instance, where "half a league" of wood belonged to Fincham, half an acre to Westbriggs, an acre to Stow Bardolph, 16 acres to South Runcton, and 4 acres to Barton Bendish. Stonham Aspall, in Suffolk, had $1\frac{1}{2}$ acres of woodland and 28 acres "part-woodland." There were a few other examples of acre measurements also.[1] But the usual formula in the Little Domesday ran thus: "there is pannage for x swine," because pigs constituted an important element in medieval economy, and they fed upon acorns and beech-mast. The extent of woodland was usually estimated by the number of pigs which it could feed, or by the number of pigs derived from it by way of rent. Sometimes the actual number of pigs fell far below the possible number. At Bergholt, in Suffolk, there was woodland for 1000 swine but only 29 were on the manor; while in the Suffolk hundred of Lackford, and in other places too, some pigs were entered with no mention of wood or pannage.

How accurate were these figures? In the case of the larger entries of several hundred swine or so, the round numbers may have been estimates rather than actual amounts, but, on the other hand, there are many instances of very detailed figures that suggest exactness. Occasionally the record was very precise indeed, as in the case of "Strincham" (Itteringham) in Norfolk, where there were two sokemen who had "wood for 18 pigs and 2/3 of another . . ."[2] More than one entry returned woodland of as few as 3 pigs. On the accompanying map (Fig. 5) the numbers 80 pigs, 500 pigs, and 1000 pigs have been chosen as index numbers to show moderate, large, and very large, amounts of woodland, respectively. The practice of intercommoning complicates the treatment of these figures, but, where there were a number of adjacent villages all responsible for wood-profits, we may safely conclude that they lay in a wooded district.

In Norfolk, the region with most wood lay within a belt 5 miles on either side a line drawn from Cromer to East Dereham and thence to Diss; the greater part of this country was boulder-clay land. To the north-east however the

[1] In Norfolk, Bittering had 7 acres, Sparham had 6 acres, Fakenham had 60 acres, Hardingham had 3 acres, while at Colekirk there was a wood called Fangeham Wood "sixty acres in length." In Suffolk, Hemingstone had 14 acres of wood. Forest mares were occasionally mentioned.

[2] Folio 196b: "silva de. XVIII. porc.$^{\text{t}}$ & 11 part.$^{\text{t}}$ alti.$^{\text{s}}$" This raises a number of points. Some comparison with the "semibos" of F. W. Maitland suggests itself ('Domesday Book and Beyond' (1897), p. 142). Here it must be sufficient to say that feed for "half a cow" is known in law as feed for a cow for half the year (J. Williams: 'Rights of Common' (1880), p. 49).

Fig. 4. Plough-teams in 1066

Fig. 3. Recorded adults in 1086

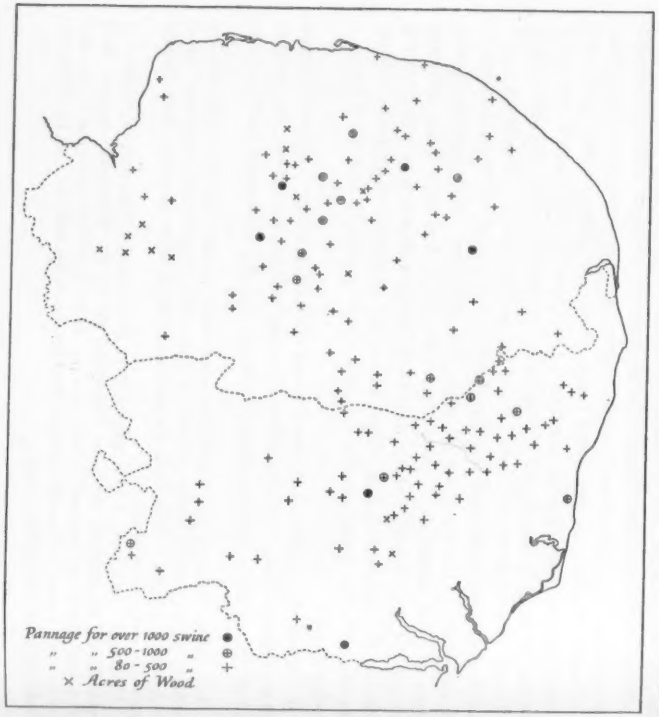



*Fig. 5. Distribution of Woodland in 1066*

*Fig. 6. Distribution of Sheep in 1066 (1 dot = 20 sheep)*

woodland overlapped on to the loam district; but in the north-west, where the clay was interspersed with sand and gravel, wood was sparse. South of the Waveney Valley were the Suffolk woodlands, stretching from Bungay through Halesworth to Debenham; this tract likewise was largely covered with boulder clay. In the extreme south-west of Suffolk, just north of Haverhill, there was an outlier of the Essex woodland (9). It is interesting to compare this distribution of woodland with the map showing the "Distribution of Soil Types" compiled in the Department of Agriculture at Cambridge (10). Such a comparison shows that some clay areas had little or no wood, but this may have been the result of clearing. It must be remembered that the state of affairs shown by the map only represents one phase in the story of East Anglian deforestation. Clearings in prehistoric, as in later, times were no doubt frequent. In the latter half of the eleventh century however the jar of conquest and the numerous changes in land ownership seem to have accelerated the process of clearing. A reduction of woodland was recorded for 28 places in Norfolk, and 28 in Suffolk also. In some cases the woodland in 1086 was reduced to one-fifth its size twenty years earlier; and reductions to one-half were frequent. Here are some examples:

| | 1066 | 1086 |
|---|---|---|
| *Norfolk* | | |
| Baconsthorpe | 40 swine | 30 swine |
| Baxton | 1000 | 200 |
| Cawston | 1500 | 1000 |
| Colby | 12 | 8 |
| Gateley | 300 | 80 |
| Woodrising | 200 | 166 |
| *Suffolk* | | |
| Coddenham | 180 | 113 |
| Framsden | 80 | 40 |
| Helmingham | 74 | 64 |
| Homersfield | 600 | 200 |
| Mendlesham | 1000 | 800 |
| Parham | 20 | 10 |

Numerous later assarts continue the story right down the Middle Ages, and the fragments of woodland, marked on the earliest English county maps some time after the close of the Middle Ages, register a further stage in the process.

*The Distribution of Sheep*

Sheep occupied an important position in Domesday economy as producers of milk and cheese. They were important in other ways too; among the services that stood out prominently in the East Anglian Survey was that of fold-soke, *soca faldae*, which was often the one definite service that a lord received from his freemen—a man's sheep had to lie in the lord's fold and so manure it.[1] Finally, they were important for their wool, which was to become one of the main foundations of East Anglian prosperity.

[1] Curiously enough, the Norfolk hundreds in which foldsoke is mentioned, *i.e.* Clavering, Loddon, Humbleyard, Henstead, Deepwade, Walsham, Clacklose, and Smethden, are not the hundreds where Domesday places the largest number of sheep. It is possible that the privilege of free-fold may have played some part in the greater development of sheep-farming in other parts of the county; but of course no definite conclusion can be drawn.



Fig. 6. Distribution of Sheep in 1066 (1 dot = 20 sheep)

Fig. 5. Distribution of Woodland in 1066

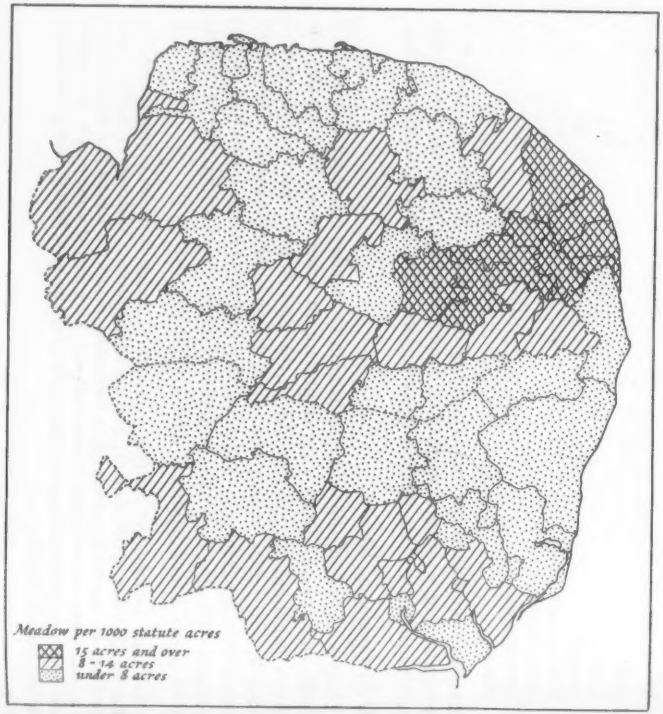



*Fig. 7. Domesday Acres of Meadow in 1066*

*Fig. 8. Domesday Saltpans*

One thing is immediately apparent from the map (Fig. 6) showing the distribution of sheep—that they were least numerous where there was most wood. They were to be found on either side the wooded belt, chiefly in the west but also in the east. In Norfolk, the largest flock of sheep numbered 1300, and was attached to the Marshland town of Walton. It is interesting to note that the other area in Norfolk where sheep were most numerous was in the south-east of the county around the marshy estuaries of the Bure and the Waveney. In Suffolk, sheep were distributed far more evenly throughout the county; there were flocks of one hundred sheep or more in every hundred except that of Loes and the half-hundreds of Parham and Ipswich. But it was in the Breckland hundred of Lackford that they were most numerous: in the royal manor of Mildenhall there were 1000 sheep with 500 in the dependent berewick of Icklingham, and at Downham and Eriswell there were large flocks of 900 and 800 respectively. Of course it must be remembered that these statistics give the stock that was on the demesne of the manors.

There seems to have been considerable intercommoning and, on that account, we cannot lay any great stress upon the topographical accuracy of the sheep-map. The Suffolk Survey contains one famous reference to "a certain pasture common to all the men of the hundred" of Colneis in the south-east corner of the county—a perfect illustration of the practice of the intercommoning of several villages. Many Domesday statistics can only be explained on the assumption of such intercommoning; and some present-day parish boundary patterns may be nothing other than fossilized relics of an older economy, providing a commentary upon these facts and suppositions. In later times, we know that the animals of seven Marshland villages in Norfolk pastured upon Tilney Smeeth, and the modern parish map shows the Smeeth as consisting of detached portions of these villages: one space of only 36 acres has been divided among six villages; the whole arrangement points back to a time when the locality was held in common. Broadland, in the east of the county, is likewise an area of detached parishes. In most cases the Domesday entries leave us to infer the existence of pastures from the number of stock, but the map (Fig. 7) showing the distribution of meadow-land speaks for itself.

*Fig. 8. Domesday Saltpans*

*Fig. 7. Domesday Acres of Meadow in 1066*

*Miscellaneous Data: Mills, Fisheries, and Saltpans*

Mills occupied an important place amongst the miscellaneous information which the Survey provided. They were constantly mentioned and, like the churches, they were divided among many owners, so that we may read of thirds and fourths and even sixths of mills. Naturally they were scattered along the river-courses; but occasionally some concentration was apparent. Thetford for example was responsible for no less than 7 mills, one of which brought in £1 12*s.* a year. The produce of these mills was variously stated; sometimes in terms of grain; sometimes partly in grain and partly in money; more rarely in terms of the mill fishery. But fisheries and fish-ponds, existing quite apart from mills, were very frequent. There was mention, for instance, of four fisheries and a fishing boat in Ely connected with Richard Fitz-Gilbert's estate at Lakenheath on the edge of the fen; not far away, Hockwold had 6, and Methwold 7, fisheries. Curiously enough, these fisheries were not

always recorded in places where we might expect them; there may be a complete absence of coastal fisheries in Norfolk.[1] If we read the Domesday statistics correctly, the sea played but little part in Norfolk life during the eleventh century. Similarly, the Norfolk fenland did not approach the adjoining south Lincolnshire fenland in the number of its fisheries. Isolated fisheries are recorded for some villages, but they do not rival the fishing centres at Spalding and Bourne to the north. Things were very different in Suffolk. The 24 Yarmouth fishermen[2]; the curious "seaport" at Frostenden; the numerous herring-rents in the coastal hundreds—these things remind us continually that we are in a maritime county. The abbot of Bury had a "seawer" (*heia maris*) at Southwold, and derived a rent of 25,000 herrings from his manor there. The herring rents of Beccles and Dunwich were 60,000 herrings each; and many inland villages had to provide one or two thousand herrings yearly.

One valuable product of the sea in both counties was salt (Fig. 8). Rock-salt was unknown in the eleventh century, and the supply of salt was therefore dependent upon inland brine springs or upon coastal pans for obtaining marine salt by evaporation. In Suffolk there were saltpans in the coastal hundreds of Blything and Samford and in the half hundred of Lothingland; 14 villages were named altogether. In Norfolk the salt industry was much more important, and saltpans were entered for some 60 villages. The industry was confined almost exclusively to the hundreds of Freebridge and East Flegg (and to some extent in West Flegg also), around the western and eastern marshlands respectively. On the north coast, between these two groups, the only saltpan recorded was at Burnham. The largest block of saltpans was found at Caistor, near Yarmouth, where there were 39 belonging to 8 freemen who held them under the king, and 6 belonging to the Abbey of St. Benet of Hulme. That their number constantly fluctuated is shown by some figures from Freebridge Hundred:

| | 1066 | 1086 |
|---|---|---|
| Gaywood .. .. .. .. .. | 30 saltpans | 21 saltpans |
| West Walton .. .. .. .. .. | 22 | 24 |
| South Wooton .. .. .. .. .. | 20 | 14 |

In this hundred, saltpans were actually named only in three Marshland villages; but on the adjoining upland there was a great cluster of villages responsible for the profits of saltpans. These latter may emphasize the fact that the Domesday Inquest was not a territorial survey so much as a geld book, and it is very possible that some of the upland saltpans may have been actually located in Marshland itself.

*Towns and Markets*

Any reference to urban life in Domesday times must raise more questions than it can answer. One thing that we can be certain of is the fact that there

[1] We cannot be certain that the fisheries recorded for Hunstanton, Heacham and Castle Rising were sea fisheries. The Norfolk Domesday unlike the Suffolk Domesday is even silent about the Yarmouth fishery: it is not impossible that the rent of 2000 herrings paid by Thorpe, near Norwich, really came from Yarmouth.

[2] Yarmouth as a whole was entered under Norfolk, but the Yarmouth fishermen are to be found among the entries for Suffolk.

had been changes between 1066 and 1086. In many towns the immediate effects of the Conquest seem to have been adverse.[1] At Norwich there had been 1320 burgesses in 1066, and the city probably ranked next to London and York in size. Situated on a navigable river, the Yare, it was in easy touch with the wider commerce of Northern Europe. But in 1086 the city contained no more than 665 burgesses, together with 480 bordars who paid no custom on account of their poverty. Empty houses are frequent items in its description; the building of the castle had taken the sites of 98; and many of the burgesses had left the city. The Norwich figures "defy intelligent analysis" (11), but the Little Domesday expressly states that the community had suffered much from fire, from forfeitures after Earl Ralph's rebellion, and "by reason of the King's geld." But, on the other hand, the conquerors added a French borough to the old, and this new creation was rapidly growing. In Thetford the story is similar; there had been 943 burgesses in 1066, but in 1086 this number had been reduced to 720, and there were 224 empty houses. Yarmouth however had remained in much the same condition with 70 burgesses.

To the south, in Suffolk, Ipswich had suffered severely. In 1066, 538 burgesses rendered custom to the king; twenty years later there were only 210 burgesses, of whom 100 were so poor that they could only "render to the king's geld but one penny a head" and moreover the city contained 328 waste houses unable to contribute anything to the geld. Standing in great contrast to this state of affairs was the progress of Dunwich; the number of its burgesses had risen from 120 to 236, with 24 Frenchmen and 178 poor men. Its customary rent was £50 and 60,000 herrings. But the encroachment of the sea, which was to prove its undoing, had already begun. The record is terse but eloquent enough: "then 2 carucates of land, now 1. The sea carried away the other." Apart from these, there were four other places in Suffolk where burgesses were recorded—Sudbury (118), Clare (43), Beccles (26), and Eye (25). Of the occupations of all these burgesses there is little direct evidence, but the facts can be interpreted to show that many were engaged in trade; the 538 burgesses of Ipswich for example held only 40 acres of land between them in 1066; the greater number must have been landless and dependent on a craft or upon commerce for their livelihood. Curiously enough, there are only some casual references to the important later centre of King's Lynn. Bury St. Edmunds, too, was recorded merely as the *villa* "where rests enshrined Saint Edmund King and Martyr of glorious memory." But its entries are most significant because they provide a notable example of the way in which commercial centres were growing up at this time (12). The accretion around the monastery between 1066 and 1086 had been considerable:

> "For now the town is contained in a greater circle, including (*de*) land which then used to be ploughed and sown; whereon there are 30 priests, deacons, and clerks together (*inter*); 28 nuns and poor persons who daily utter prayers for the King and for all Christian people: 75 bakers, ale-brewers, tailors, washerwomen, shoemakers, robe-makers (*parmentarii*), cooks, porters, agents (*dispensatores*) together. And all

[1] Taking the area as a whole, there would seem to have been considerable improvements in the value of land. Thus land values in Norfolk rose from £2219 2*s*. 11*d*. in 1066 to £4154 11*s*. 7*d*. in 1086, and this compares very well with other counties. See C. H. Pearson, 'History of England during the Early and Middle Ages,' 2 vols. (1867), pp. 661–670.

these daily wait upon the Saint, the Abbot and the Brethren. Besides whom there are 13 reeves over the land, who have their houses in the said town, and under them 5 bordars. Now 34 knights, French and English together, and under them 22 bordars. Now altogether (there are) 342 houses in the demesne on land of Saint Edmund which was under the plough in the time of King Edward."

But it must be remembered that the rural character of these towns was still very strong. There was more than a smack of the farmyard about the borough. Even in Clare, for instance, where there was a market, the urban element is somewhat obscured by rural detail—the woodland, the mill, the vineyard, the farm-stock, the ploughs. It may be significant that of the 43 markets recorded in the Domesday Book only eleven were situated in places where there were burgesses. Of these 43 three were mentioned in Norfolk—at Downham, Colney, and Litcham; and nine in Suffolk—at Thorney (in Stowmarket), Beccles, Sudbury, Blythburgh, Eye, Kelsale (*?Caramhalla*), Haverhill, Clare, and Hoxne. We know from other sources that there was a good deal of rivalry between the markets of neighbouring localities in the Middle Ages. Later custom laid down that a market could be called a nuisance if it were set up within 6 to 7 miles of another. Just once in the Little Domesday the veil is lifted for a moment to give a peep upon such antagonisms in East Anglia:

"In this manor (Hoxne) there used to be a market in the time of King Edward and (it continued) after King William came hither; and it was set up (*sedebat*) on Saturdays. And William Malet made his castle at *Eia* (Eye), and on the same day as the market used to be held on the Bishop's manor William Malet made another market in his castle and thereby the Bishop's market has been so far spoilt that it is of little worth; and now it is set up on Fridays. But the market at *Heia* is set up on the Saturday."

These fragments of commercial information are all very unsatisfactory, and it is impossible to say how far they really indicate the urban and commercial life of the two countries. All one can say is that Suffolk with its many groups of burgesses, its markets, and its sea-coast activity, seems to have been a county of some trade and commerce. But the compilers of the Domesday returns, in giving us something, have indeed withheld much.

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(3) Cyril Fox: 'Archaeology of the Cambridge Region' (1923), pp. 306–12.
(4) H. Lindkvist: 'Middle English Place-Names of Scandinavian Origin' (1921), p. xxxix.
(5) Walter Rye: "Pedes finium relating to Norfolk. 3 Richard I to the end of the reign of John," *Norf. and Norwich Archaeol. Soc.*, 1881.
(6) H. Peake: 'The English Village' (1922), p. 116. See also Lindkvist, *op. cit.*, p. lvii. For tenurial peculiarities in East Anglia, see H. L. Gray: 'English Field Systems' (1915); and D. C. Douglas: 'Social Structure of Medieval East Anglia' (1927).
(7) Henry Ellis: 'A General Introduction to Domesday Book,' 2 vols. (1833).
(8) J. H. Round: 'Feudal England' (1909), pp. 98–103, on the East Anglian "Leet." For the data, see (1) Charles Johnson: "The Danegeld in

Norfolk," in V. C. H., Norfolk, vol. i, p. 204, and (2) Beatrice A. Lees: "The Danegeld and Leet System in Suffolk," in V. C. H., Suffolk, vol. i, p. 412.

(9) H. C. Darby: "Domesday Woodland in East Anglia," *Antiquity*, 1934, p. 213.

(10) 'An Economic Survey of Agriculture in the Eastern Counties of England, 1931' (Heffer, 1932). See also H. H. Nicholson and F. Hanley: "Soil Conditions in East Anglia," *Empire Jour. Exper. Agric.* vol. viii, p. 60.

(11) Carl Stephenson: 'Borough and Town' (1933), p. 198. Note also Stephenson's general discussion of the problems connected with "burgenses."

(12) M. D. Lobel: 'The Borough of Bury St. Edmunds' (1935), pp. 10–15.

## DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX, G.C.M.G.) said: My lord, ladies and gentlemen, According to the notices that first went out Major Bagnold was to address us this afternoon on the movement of Devon sand. Unfortunately he went down with appendicitis, and was not able to fulfil the engagement, but I am glad to say that he is now almost recovered. Dr. Darby, who is with us, has very kindly stepped into the breach, and is going to address us on the subject of "The Domesday Geography of Norfolk and Suffolk." Dr. Darby is a Fellow of King's College, Cambridge, and a student of medieval geography. In his paper he starts with the Anglo-Saxon period, which he considers a good point of departure, and works up to the Domesday Book. The Domesday Book, as you all know, is in two volumes, the second of which treats of Norfolk, Suffolk, and Essex, while the first treats of the rest of Great Britain with one or two counties excepted. Owing to the fact that the second volume treats only of three counties, the information given in it is much fuller. The Domesday Book is now kept at the Record Office in London, where any one can see it by going to the museum there, and I may mention that we have two members of the Record Office staff with us this afternoon, and I hope they may like to say a few words after the paper.

*Dr. Darby then read the paper printed above, and a discussion followed.*

The PRESIDENT: We have with us Mr. J. N. L. Baker, who is a member of the School of Geography at Oxford, and I will ask him to open the discussion.

Mr. J. N. L. BAKER: Mr. President, I speak with great diffidence after listening to Dr. Darby because I am not in any sense an expert in medieval history, and in my judgment no one but an expert in medieval history should deal with such a complicated and difficult subject as the Domesday Book. I should like, as a student of historical geography, to offer my congratulations to Dr. Darby on the production of a paper which I am quite certain will be of great use to many other students who are working on similar questions of historical geography relating to other parts of the country. One has only to compare the technique both of the paper itself and of the maps that Dr. Darby has produced with the historical geography that was taught by Freeman, for instance, or with the historical maps that were produced by Pearson in his Atlas of Historical Maps of England, to see how far academic geography has advanced in the study of historical geography within a comparatively short time. And it is just because Dr. Darby's paper is likely to act in a sense as a model for others that I would suggest additions to it on one or two points when it comes to be published.

First of all, we have been shown a map giving the density of population. Dr. Darby did not tell us the source of his information, but presumably his figures

were obtained from Ellis's well-known tables.[1] If I remember rightly, the total population given in those tables was about a quarter of a million people.[2] It seems a trifle misleading to plot those figures on a map and call that a map of the density of population in 1086. I think it would be better to state that the map shows the relative importance of the counties in respect of population, because I do not think anybody knows what the figures of population in Domesday Book meant, and what proportion they bore to the total population of the country.

A similar remark may be made with regard to those instructive maps showing the distribution of woodland. The only detailed study of Domesday I know is that by Mr. G. H. Fowler, who has produced the Domesday of Bedfordshire, and has illustrated it with a large number of maps.[3] His technique is entirely different from Dr. Darby's. He has plotted out all his Domesday figures in relation to present-day parishes; of course, he makes many reservations, and is fully aware of the difficulties. We have in Dr. Darby's paper an entirely different technique, and it would be of value to those who may try to adopt his methods in other parts of the country if some further guidance were afforded. Mr. Fowler, for instance, adopted the convention of 1½ acres of woodland to one pig. Dr. Darby has adopted an entirely different convention, and it would be interesting to know why he has done so, and to have his views as to whether he thinks the methods he has adopted are likely to produce better results than those of Mr. Fowler.

The PRESIDENT: We have with us Dr. Wooldridge, of King's College, London, whom I will ask to speak.

Dr. S. W. WOOLDRIDGE: Mr. President, I should like to join with Mr. Baker in expressing my deep interest in this lecture, which I think we may regard as the beginning of a work, perhaps long overdue, that of putting certain Domesday data on the map. I am not so sure that Mr. Baker's attitude is the right one to adopt in regard to this work, because I am bound to believe that it is better to put things on the map in any case than to leave them out, on account of technical difficulties. It is well that we should realize that in the Domesday records we have a vast body of accurately located facts, and Dr. Darby has gone on to produce something where many of us have attempted it and stopped before reaching a conclusion. Students of my own have attempted this work, particularly in Essex and Hertfordshire, but I shall not make any detailed reference to that work except to say that there, of course, precisely the same difficulties are encountered. I may add that in the case of Essex, as Dr. R. C. Coles has shown, it is possible to confirm the distribution of woodland as shown by pannage for swine by comparison with certain later perambulations, and to obtain a very consistent picture of the gradual disappearance of forest.

The conditions, as you may have noticed from Dr. Darby's map, are very different in Essex from what they are in East Anglia, and that may possibly account for a few discrepancies—or differences of opinion at least—in respect of the physical matters which figured in Dr. Darby's introduction. If I understood him correctly, he would represent the boulder-clay land as the most heavily wooded, though he refers in the abstract to the boulder clay in the east of the area as being less tenacious than the clays of the Weald and other parts of the country. Looking at the matter from the Essex angle, I should arrive at a different conclusion, and regard the boulder clay as a readily cultivated soil, in a relative sense, and the heavier clays as a totally different group of substances, geographically considered.

[1] 'General Introduction to Domesday Book.' By Sir Henry Ellis, 1833.

[2] 283,242.

[3] 'Bedfordshire in 1086.' Memoirs of Bedfordshire Historical Record Society, 1922.

That leads me to another point on which I should like guidance. I do not think there is any valid distinction between the loams of north-east Norfolk and the soils of parts of what we call the boulder-clay area. We are always in danger of taking from the geologist his ready-made classification without adapting it to our purposes. In Essex large parts of the boulder-clay land have the character of loam country, and I think the same is true of large parts of Norfolk, though not of Suffolk. There is a real and valid distinction between the chalky boulder clay of Norfolk, which gives rise to the light soils, and the heavier boulder clay of Suffolk. Has Dr. Darby had the opportunity of comparing the distributions with the soil map of East Anglia produced by the Cambridge School of Agriculture? So far as that map concerns Essex I find it closely in accord with some of the older human distributions of that county. Nothing less than a real attempt to distinguish between what is loam and what is clay will suffice in dealing with the geographical distributions.

I congratulate Dr. Darby on a very courageous piece of work—the assembling on the map of the vital data of the Domesday Book; I trust that similar work in other regions will contribute to the building up, before long, of a general regional picture for the period.

The PRESIDENT: Miss J. B. Mitchell is a student of Newnham College, Cambridge, who has made a special study of this side of geography, and I will ask her to speak to us.

Miss J. B. MITCHELL: Mr. President, I should like to add my thanks to those of Mr. Baker and Dr. Wooldridge to Dr. Darby for his most interesting paper, and to express a very deep appreciation of the work he is doing in utilizing the Domesday Book and other records to suggest a reconstruction of the geographical facts of past periods. Dr. Darby shows that in the eleventh century the sheep of Norfolk appeared to be pastured mainly on the marshy areas, while those of Suffolk were more generally distributed. The values of the wools in the fourteenth century suggest a similar distribution. In the counties bordering on East Anglia—Essex, Lincoln, Surrey, Sussex, and Kent—wool is divided into two groups, a better quality and a cheaper quality, and the cheaper quality is definitely said to be wool of the marshlands. In Norfolk all the wool is valued at seven and a half marks per sack, the exact value of "wool of the marshes" elsewhere, which may suggest that still in the fourteenth century the greater portion of it was produced in the marshland area. Further, a distribution map which I have been trying to make for the thirteenth century of the hundred of Blackbourne, Suffolk, again suggests, as Dr. Darby showed from an earlier period, that where the sheep are numerous the pigs are few. In this case the more definitely agricultural areas suggested by grain production, and greater numbers of cattle and horses, also show very few pigs. I should like to know whether Dr. Darby finds that in the Domesday Survey, pigs are rare in areas where cattle are unusually numerous as well as in areas returning large numbers of sheep.

The PRESIDENT: Our Librarian, Mr. Crone, has interested himself in this subject, and we should like to hear a few words from him.

Mr. G. R. CRONE: I should like to associate myself with what has been said as to the interest of Dr. Darby's work. These problems of the Domesday Book are an attractive subject for inquiry, but, as will have been realized from what he has said, the subject needs careful handling, and is one of the most controversial in English history.

As other speakers have already dealt with the geographical aspect, perhaps I may be allowed to put two questions from the historical point of view. There has always been much dispute about the proportion of the population which Domesday Book actually covers. One school holds that by working from the

figures given it is possible to calculate fairly accurately a total figure for the population of that time somewhere about one and a half millions. But others maintain that the Domesday Book deals only with the people in whom the Crown had an interest, that is, those who were a source of revenue to it, and that to get any proper idea of the population of that time it is necessary to multiply the total by a considerable figure. In systematically examining the Domesday Book for a particular area it occurred to me that Dr. Darby might have come upon some clues which afford an answer to that question. Perhaps he can tell us whether there are gaps which suggest that there are additions to be made to the population, or alternatively what population the cultivated areas suggest. If Domesday is simply a record of taxpayers, then the total population may have been very much greater than that actually returned.

I was not quite clear about the extent of woodland, and whether or not the whole of the forest land was included. Apparently in this twenty-year period—1066 to 1086—deforestation went on very rapidly; reductions to one-half the woodland, Dr. Darby says, were frequent, and in some parishes the reductions were much greater still. That suggests that a good deal of colonization must have been going on, and this in a relatively disturbed period, not particularly favourable to colonization, when, as Dr. Darby has told us, the population of Norwich and other towns was declining. It would be interesting to have an explanation of this apparent contradiction. As to the nucleated and scattered villages, it has been said in the past that the former were Teutonic and the latter Celtic. That might be true on the edge of the Marches, but it is interesting to have further proof that this question is geographical and historical and is not entirely a question of race.

The PRESIDENT: I now call upon Mr. East, of the London School of Economics.

Mr. W. G. EAST: Mr. President, ladies and gentlemen, it seems to me, in the first place, a very good thing that we should have heard here a paper of this kind. We have had from time to time outlined to us by Sir Halford Mackinder the purpose and nature of historical geography, and some of us do believe that in geography, conceived as a space-time continuum, evolutionary changes deserve important consideration in relation to the study of things as they are.

A second comment is this. What an amazing thing it is that English geography is so young and so backward that nothing has yet been done geographically to solve the Domesday riddle. Here is a document which has a definite geographical message if only we can read it, and only now is the attack on that document from the geographical standpoint beginning. It does seem to me to emphasize the fact that on the geography of this country, in particular in certain of its aspects past and present, study has scarcely begun. The Domesday chapters in the Victoria County History were written or conceived before modern geographical problems had been formulated. Therefore I agree with previous speakers in believing and hoping that this paper may become the precursor of a whole series of studies carried on in a similar though not necessarily identical way with a view to collating results in different parts of the country, so that we can build up a picture, not only of the factors brought out in the Domesday Survey, but also of any other factors which may be discovered in the geographical environment of that time. I feel hardly at one with two of the previous speakers. Dr. Wooldridge suggests that any data, despite the difficulties in its interpretation, should be put on a map. I feel that it is unwise to map material about which one is far from clear. It is important to see clearly what is put on the map. On the other hand, I would not agree entirely with Mr. J. N. L. Baker in suggesting that only medieval historians should interpret Domesday. I feel that geographers, if they are sufficiently keen, can muster the necessary technique

required for dealing with a period of this kind. I do not believe that historical research is beyond the scope of the intelligent geographer.

One detailed point. The method Dr. Darby employed of using pannage for swine to indicate woodland struck me as ingenious, and for the counties with which he is concerned that method has a great deal to recommend it, though it is not generally applicable to other regions less thoroughly settled, *e.g.* the Weald, where it would break down. I should like to know more about the ecological conditions of East Anglia: what kinds of forest and what kinds of loam soils predominate in those counties. Is it true that pigs will browse happily in deciduous forests of all kinds, or only among the oak or the beech? Further, I feel very dubious, in fact, utterly incredulous, about the deforestation that Dr. Darby appears to deduce from his Domesday figures. It seems to be implied that something like half the forest land in part at least of these counties disappeared in twenty years. Yet that was not a time, so far as one can judge, of increasing population and colonization. History proves that deforestation goes hand in hand with colonial activity, and if, as it seems from Dr. Darby's showing, the population was declining if anything, it does not seem likely that during such period the forests would be drastically curtailed.

One word of criticism with regard to the figures which Dr. Darby has taken. Was it wise to use the 1066 figures for the mapping? Would it not have been wiser to have used the 1086 figures, which were figures contemporary with the Survey? The 1066 figures depended on the memories of conditions twenty years earlier, and that being so I should think the 1066 figures must be the less credible and reliable of the two.

The PRESIDENT: Perhaps one of the Record Office staff would like to say a few words.

Mr. R. L. ATKINSON: I am afraid I have not very much to say beyond thanking Dr. Darby very much indeed on behalf of my colleagues for the very excellent use he has made of Domesday material, and to express the hope that the Editor of the *Journal* will be generous in the amount of space he allots to the reproduction of Dr. Darby's maps, because they will be a very useful addition to the material we have in the library of the Record Office. I have long felt that a great deal more modern research on Domesday is overdue. The amount of modern addition to the Domesday Survey is very unevenly distributed. Of the thirty-four counties covered in the Domesday Survey only about twenty-four, I think, are edited in detail in the Victoria County History, another five or six have been edited in some detail by local societies, but there are still some counties of which there is no modern edition at all, and something of that kind is very much overdue.

The PRESIDENT: The Victoria History is still being published?

Mr. ATKINSON: It is, and I hope they will go on with the Domesday sections first if they can; but it has taken a very long time to cover what that history has done, and there is a great deal more to be done.

The PRESIDENT: I will ask Dr. Darby to reply, if he cares to, to points raised in the discussion.

Dr. DARBY: I agree with Mr. Baker about the density of population. It is a caution greatly needed, and on my map the legend read, "Recorded Adults per square mile," which, I hoped, might afford a sort of scale; the map did not attempt to represent actual population. For our purpose it gave an indication of comparative prosperity, and that is all one can hope to get. Mr. Baker's second point about the different methods of plotting is also very relevant. The method he mentions I have used for one or two hundreds in Norfolk, and it is quite suitable for small areas, but in dealing with large areas too many reservations are needed. The slide I showed you is a simpler method of giving the

information. But it is very interesting to compare the appearance of two maps based on the different methods of plotting. That however is an experiment in mapping. There is one further point. The Domesday entries are conventionalized enough as they stand without any further convention to complicate the situation.

Dr. Wooldridge's first point emphasizes the difficulties of this matter. My comment is the same, that half a loaf is better than no bread. And in some cases we can get, not the whole truth, but three-quarters of the truth. His second point about boulder clay is of importance. You saw that on the settlement map there was no distinction between loam areas and boulder-clay areas. I must thank Dr. Wooldridge for mentioning that point, for it explains the distribution of the settlement, and illustrates what I stressed—the danger of generalization. Miss Mitchell's work, I know, affords an example of meeting the need for using later perambulations and later surveys. Such work as she is doing will have to provide the sequel to the Domesday geography of East Anglia.

The Librarian's point emphasizes that made by Mr. Baker. But I am not concerned with total figures. The real difficulty is to produce the actual population from the Domesday figures; and, here again, I can but say that the geld-assessment and population maps only give an indication of prosperity. In particular they may not represent very well the non-agrarian elements in the population. Mr. Crone also asked how far the swine map represents the distribution of woodland. Let me say quite clearly that for Norfolk and Suffolk I think it does represent the real distribution. For other counties such a swine-map may not reflect the actual woodland. When I plotted out the distribution of swine in Sussex I found that they were absent from the very areas where I had expected to find wood, because the woodland had not been settled at that time. In East Anglia, swine give a good indication of woodland because the villages were close together, and there were no wide uncleared areas of wood.

Mr. East raised the point about changes in ownership and the prosperity of the times between 1066 and 1086. The actual values of land rose considerably in Norfolk and Suffolk, which shows that, though the times were uncertain, a good deal of development was proceeding. Further, change in land ownership might quite conceivably involve clearing of the wood. Despite the clearings there is very little difference in pattern between the distributions of wood in 1066 and 1086, because every village did not clear its wood in this manner. Sometimes the clearing was on a surprisingly large scale, but, more frequently, on a very small scale, and the main outline of the distribution was preserved.

Finally, I must thank the speaker from the Public Record Office (Mr. Atkinson) for his plea for the inclusion of the maps, to which I hope the Editor has listened!

The PRESIDENT: We are very greatly indebted to Dr. Darby for giving this paper, and it is evident from the comments of the speakers in the discussion that it is of very great importance. We shall endeavour to do justice to it in the *Journal*. I cannot discuss the details of his paper and the views which he has expressed; but it does seem interesting to know that the population was once computed in terms of pigs! We thank Dr. Darby very much for giving us this important paper, and hope it will stimulate further research in a direction in which there is evidently a great field for it.

# AN UNDESCRIBED ELIZABETHAN MAP

EDWARD HEAWOOD

BY the courtesy of its owner, Mr. E. Zaehnsdorf, we have been permitted to examine and display at the Society's House a striking example of Elizabethan cartography which has hitherto escaped the notice of students of early English maps. It represents the harbour of Rye as it was in those days together with the various waterways debouching thereinto and the country in its near neighbourhood. It bears the date 1594 and, though unsigned, may with confidence be attributed to the noted surveyor and map-maker, Philip Symonson, of Rochester, author of the first at all adequate map of Kent as a whole, with roads inserted, bearing the date 1596, the eastern half of which was reproduced in the Society's recent collection of engraved county maps (No. 10 of the set) from the unique copy of the original issue owned by Canon G. M. Livett. For its careful and pleasing style of execution the Rye map may rank with the best specimens of MS. map-work of the Elizabethan period, and as the surviving examples of this are all too few deserves somewhat full consideration. In putting together the following notes we have had the advantage of data kindly supplied not only by the owner himself, who has been at some pains to establish its authorship, but of two competent authorities on the history of Rye and its neighbourhood—Mr. L. A. Vidler, author of a history of the place published only last year, and Dr. F. W. Cock, of Appledore in the adjoining part of Kent, who has long devoted himself to a study of Kent antiquities, and to whose sagacity the first suggestion of Symonson's authorship must be credited.

Besides his published map of Kent, finely engraved by the Englishman Charles Whitwell (one of the few who down to that time had begun to emulate the work of Dutch and Flemish craftsmen), Symonson has been known for various local surveys, three of which still exist in MS. and are preserved among the archives of the Bridge Chamber at Rochester. They were briefly described by the late Sir George Fordham at the Leeds Meeting of the British Association in 1927, in a paper printed in this *Journal* in January 1928 (vol. 71, pp. 50 *et seq.*). As there mentioned, Symonson was Mayor of Rochester in 1597/98, and held the post of Surveyor and Manager of the Bridge Estates from 1592 till his death in 1598. None of the three plans is signed, but their authorship is vouched for by entries in the Rochester Archives recording payments to Symonson for these very plans, while all agree in style, both as regards the script and other details. The most important is that of the Manors of Nashenden and Little Delce, near Rochester, owned, with other lands surveyed by Symonson, by the Bridge Wardens, and this has been courteously lent to the Society for exhibition side by side with the Rye map. Its style shows such a close resemblance to the latter as to afford a cogent argument for identical authorship, apart from other evidence to be shortly dealt with.

From a detailed comparison of his map with the Rochester plans, Mr. Zaehnsdorf seems justified in finding agreement in the following particulars (in many of which, we may add, the engraved county map closely follows suit). The ground contours are similarly drawn, while churches, houses,

etc., are shown in minute detail, care being taken to distinguish the nature of the church spires, towers, or steeples. The scale is drawn with great exactness and the associated pair of compasses in the Rye map is exactly matched in the Nashenden plan, even to the fluted form of its knuckle-boss, shown by a series of curved lines. The script agrees closely and the general tone of the colouring is alike, while the trees are similarly drawn (outlined with fine, often serrated, lines), and the colour of the rivers and the shading of their banks is the same. The first words of the titles are always in red and the paper appears to have a similar surface, though the mounts of the MSS. obscure any watermarks that may have been present. Lastly, a feature common to the Rochester plans is the broad black margin, and though most of this has been removed by trimming, the traces remaining in the Rye map show that it must once have agreed in this also.

Apart from such general resemblances, it may be noted that the topographical details in the Rye map are almost exactly reproduced in the relative section of the county map, the choice of names and their spellings being also practically the same. (In spite of its smaller scale, the nomenclature is slightly fuller in the county map, produced no doubt on a more deliberate plan.) Further evidence in the same direction is available in entries in the Rye Archives kindly extracted for us by Mr. Vidler. It may be recalled that the deterioration of the harbour through silting had for some time been matter for concern, and in 1591 an Italian, Gedevilo Gienily, had put forward a scheme for its improvement, rejected however by the authorities. Thereupon Symonson seems to have been called in, and must have quickly set to work on a survey of the district, for in March 1593/4 the work was well advanced, as shown by the Rye records which are worth quoting verbally:

1593/4
Mar 24. This day it is agreed that £5 shall be given to Mr. Symonson for his paynes, that he hath taken here about the making of a Plott of this Towne and contrye, whereby our Harbour may be amended & at such time as the same is finished and put in cullers, he shall be fully considered. Also that a piece of gold of 5/– be given to Lucy Phillips,
1594 servant to Mr. Symonson for a reward from this Town.
Aug. 24. This day Mr. Symonson brought and delivered to Mr. Maier and the Jurats aforesaide, a plott of the Townshippe and of the waters, Parishes and grounds adjoining, whose recompense therefore is differed and referred to an Assembly shortly to be taken. It is ordered that 16/– be paid to Mr. Bett, which he paid to Mrs. Didsbury, which this Townshippe owed to her for the diet of Mr. Symonson.
Aug. 26. At this Assembly it is agreed that £5 be given to Mr. Symonson for making ii plotts for this Townshippe, wherefore Mr. Borough hath the one & the other remaineth here.

It is worthy of note that the map itself is dated the very day after the first of these entries, and that the title reveals the purpose of the map as a help towards remedying the adverse conditions. This too may be quoted in full:

"The description of the decayed Harbrough of Rye, with the Courses and Concurrence of the fresh waters that fall into the same, and lykewyse the

manner of their yssuing into the sea: whereby, may be the better gathered the precedent cause of decay, as also the present meanes for remedye thereof. 25° Martij. a° 1594."

Mr. Vidler points out that the marking of "Mr. Genebellye's Mill," on the west bank of the river, half-way between Rye and Appledore, indicates that the Italian so anglicized was already working in the marsh when he put forward his scheme. Another item of interest is the insertion (apparently for the first time) of "Toote" rock on the coast south of Rye (a name which it still bears). Of local interest too is the careful way in which the windmills of the district are shown, including one in Appledore, of the position of which Dr. Cock had not been sure. While many of the churches are shown as they now are, others are represented with spires which no longer exist.

In the above extracts from the records mention is made of a servant of Symonson's, Lucy Phillips, who was to receive 5*s*., no doubt for some part he had borne in the work. Mr. Zaehnsdorf has also in his hands a smaller map, evidently a reduction from the other, though the work is altogether inferior in style, both in drawing and colouring. He suggests that this is one of the " ii plotts" for which Symonson was paid, and that it was actually drawn by Phillips, but of this there is no proof. The paper bears no watermark and it cannot be said positively that the drawing is contemporary. It is perhaps more likely that Phillips had aided his master in the actual survey. In spite of the form of the Christian name, Lucy Phillips was no doubt a man, and Mr. Vidler finds that a person of that name was admitted a freeman of Rye, 9 March, 18. Eliz., his admission being proved at Lewes on 16 March 1580/81. He can trace him as living in the Boddings ward in 1579 and suggests that he may have been father to Symonson's servant, the latter having perhaps been employed on account of his local knowledge.

A few notes on other early maps of the district, based in part on information supplied by Dr. Cock, may be added. The Public Record Office possesses a small plan, ascribed to the time of Elizabeth, which includes Winchelsea and Winchelsea Castle (the latter on a sandbank) with "Nordeam," "Pesemarsh," "Salicot," etc., and "the Saltes of Wenway Crick"; and three other small MS. plans of this period, one illustrating the project of the Italian Gienily, are reproduced in Mr. Vidler's book. Dr. Cock mentions a MS. map of 1598 showing Rye harbour and adjacent land, preserved in the Library of All Souls College, Oxford. It shows especially the Guildford shore and reveals the extent to which land was gradually being reclaimed from the waters. The marking of "the wreck of the sugar ship" is surely one of the earliest references to a West Indiaman.

Mr. Zaehnsdorf is the fortunate possessor of another contemporary map which has hitherto escaped notice, by a surveyor (or draughtsman) quite unknown to fame—one "John Stonhame." It is signed by him and dated 1599—the year after Symonson's death—and would seem to be the result of a further independent survey, as many of the outlines differ considerably from Symonson's, and, though on a rather smaller scale, it gives many details not to be found in its predecessor, while the spellings are often different. It covers a rather larger area, from Hythe ("Hyd") to Hastings, and marks all

the villages along the northern edge of Romney Marsh. Although rougher in style than Symonson's it appears to be a careful piece of work. A special feature is the marking of roads and other tracks within the marsh area. Dr. Cock refers to an "early seventeenth century" MS. map at the British Museum, but this we have been unable to trace. The most important map of the period however is that of Matthew Poker (1617), preserved in MS. in the Maidstone Museum, but available for study in Cole's engraving of 1737, which has been reproduced within recent years. It is more detailed than any of its predecessors and bears a title beginning "The Description of Romney Marsh, Walland Marsh, Denge Marsh and Guildeford Marsh, with the divisions of their Waterings, Heads, Arms, Pinnokes, Bridges, and Houses and Cottages within the said several levels." The original has the west at the top, but the compass shows as the north point what is actually about S.S.W. The water-channels are described in some detail, with the method of taking off the water by two "watering issues." It seems to have supplied the basis of a very similar map engraved for Dugdale's 'History of Imbanking and Draining of Divers Fenns (1662)' the title of which begins in the same words.

It will be seen that a good deal of material is available for the study of past changes in an area where they have been unusually pronounced.

## A PLACE-NAME PROBLEM

CAPTAIN C. H. B. GRANT

MODERN geographical research rightly demands purity of nomenclature and priority of names. To preserve on maps the place-names used by the inhabitants and residents is infinitely better geography than giving a doubtful honour to some chance visitor, but the local name must be correctly transliterated. Adherence to accepted rules and ethics is essential, but at times that exception occurs which creates a problem, and the question arises as to which line should be followed—a strict adherence to local place-names, or discreet alteration to conform to the general rules of geography.

Just such a problem is to be found in the Kondoa District of Tanganyika Territory on the road between Mtoro and Farkwa, where, $2\frac{1}{2}$ miles south-east of the Bubu river crossing, the motor road crosses the Mkenke river. Now the Mkenke river rises under other names in the north-western corner of Kondoa District, near the Kondoa-to-Singida road, and becomes the Mkenke where the Kondoa-to-Mtoro road crosses it 5 miles east of Mtoro. It therefore joins the Bubu on its northern bank and yet is also known as the Mkenke on the south side of that river. Usually it is accepted that where a smaller river joins a larger one it ceases to exist and becomes the larger one, and so, in this case the Mkenke would cease at its junction with the Bubu, and although the Bubu divides into two streams at this point to join again lower down, both branches would be known as the Bubu. The natives however argue otherwise,

and say that the Mkenke cuts across the Bubu and does not become that river until it rejoins it on its southern bank lower down.

As all natives and travellers using the Mtoro-to-Farkwa road have from time immemorial first crossed the Bubu and then the Mkenke, it seems desirable to adhere to these place-names, and in this way I have placed them on my plane-table sheets of the Kondoa District.

# THE NAMES OF COUNTRIES USED BY OTHER COUNTRIES

ON 25 December 1934 the Persian Ministry for Foreign Affairs addressed a circular memorandum to the Foreign Diplomatic Missions in Tehran asking that the terms "Iran" and "Iranian" might be used in official correspondence and conversation as from March 21 last instead of the words "Persia" and "Persian" hitherto used. On 20 February 1935 the Secretary of State for Foreign Affairs gave this information in answer to a question in Parliament, and said that His Majesty's Minister in Tehran had been instructed to accede to the request. A few days later the Postmaster-General announced that as the Persian Government had informed the Universal Postal Union of its desire that Persia should in future be known officially as Iran, correspondence for Persia should be so addressed.

We do not recall that any such action has ever before been taken by the Government of a country whose own name as used internally is not that by which the country is habitually known abroad. In particular the countries of Europe are so accustomed to the fact that their neighbours habitually use either variants or completely different names that it does not seem to have occurred to them that it was possible to remedy this inconvenience. The people of the Deutsches Reich have never we believe taken any steps to persuade the Danes to give up calling their country Tyskland, the Poles calling it Niemcy, or the English calling it Germany; and the action of the Iranian Government suggests interesting possibilities.

We have never seen any list of what countries call other countries, and as a basis for considering the Iran precedent, the Librarian, with the assistance of the Secretary of the Permanent Committee on Geographical Names, has put together the following list. The versions of a country's name that are current in other countries are influenced partly by the structure and habits of the language and partly by historical influences or old habit, of which the former are probably more intractable than the latter. Iran is a euphonious name that can scarcely be mispronounced except in English, though it may be variously stressed. But complex names may present difficulties that are perhaps insoluble. The initial of Československo must, it would seem, be written Cz in Polish, Cs in Magyar, Tch in French, Tsch in German, C in Italian, Tsj in Dutch, because there is no other method of writing this sound, which we write Ch, in these languages. There are therefore formidable difficulties which would confront some countries in inviting others to call them by their strict official name.

It must often happen to a traveller that he cannot address properly a letter posted in one foreign country to another. The vocabularies for the use of travellers generally overlook this requirement, and indeed it is not easy to be certain that dictionaries always give the form in actual use. By the courtesy of various Embassies and Legations we have checked as far as possible the list here printed, but shall expect to receive some corrections, and this we shall be very glad to do.

## TABLE OF COUNTRIES' NAMES IN EUROPEAN LANGUAGES USING THE LATIN ALPHABET

| | *French* | *Italian* | *Spanish* | *Portuguese* | *Romanian* |
|---|---|---|---|---|---|
| Great Britain | Grande Bretagne | Gran Bretagna | Gran Bretaña | Grande Bretanha | Marea Britanie |
| England | Angleterre | Inghilterra | Inglaterra | Inglaterra | Englitera |
| Scotland | Écosse | Scozia | Escocia | Escocia | Scoția |
| Wales | Pays de Galles | Galles | País de Gales | Galles | Țara Galilor |
| Ireland | Irlande | Irlanda | Irlanda | Irlanda | Irlanda |
| France | France | Francia | Francia | França | Franța |
| Belgium | Belgique | Belgio | Bélgica | Belgia | Belgia |
| Italy | Italie | Italia | Italia | Italia | Italia |
| Spain | Espagne | Spagna | España | Espanha | Spania |
| Portugal | Portugal | Portogallo | Portugal | Portugal | Portugalia |
| Romania | Roumanie | Romania | Romania | Romania | România |
| Germany | Allemagne | Germania | Alemania | Allemanha | Germania |
| Austria | Autriche | Austria | Austria | Austria | Austria |
| Switzerland | Suisse | Svizzera | Suiza | Suissa | Elveția |
| Netherlands | Pays-Bas | Paesi Bassi | Países Bajos | Paizes-Baixos | — |
| Holland | Hollande | Olanda | Holanda | Hollanda | Olanda |
| Denmark | Danemark | Danimarca | Dinamarca | Dinamarca | Danemarca |
| Norway | Norvège | Norvegia | Noruega | Noruega | Norvegia |
| Sweden | Suède | Svezia | Suecia | Suecia | Suedia |
| Finland | Finlande | Finlandia | Finlandia | Finlandia | Finlanda |
| Estonia | Esthonie | Estonia | Estonia | Estonia | Estonia |
| Latvia | Lettonie | Lettonia | Letonia | Letonia | Letonia |
| Lithuania | Lithuanie | Lituania | Lituania | Lituania | Lituania |
| Hungary | Hongrie | Ungheria | Hungría | Hungria | Ungaria |
| Poland | Pologne | Polonia | Polonia | Polonia | Polonia |
| Czecho-slovakia | Tchéco-Slovaquie | Ceco-slovacchia | Checo-slovaquia | Checo-slovaquia | Ceho-Slovacia |
| Yugoslavia | Yougoslavie | Iugoslavia | Yugoeslavia | Yugoslavia | Iugoslavia |
| Russia | Russie | Russia | Rusia | Russia | Rusia |
| Bulgaria | Bulgarie | Bulgaria | Bulgaria | Bulgaria | Bulgaria |
| Greece | Grèce | Grecia | Grecia | Grecia | Grecia |
| Turkey | Turquie | Turchia | Turquía | Turquia | Turcia |
| Persia | Perse | Persia | Pérsa | Persia | Persia |

| | *German* | *Dutch* | *Danish* | *Norwegian* | *Swedish* |
|---|---|---|---|---|---|
| Great Britain | Gross-britannien | Groot-Brittanje | Stor-britannien | Stor-britannia | Stor-Britannien |
| England | England | Engeland | England | England | England |
| Scotland | Schottland | Schotland | Skotland | Skotland | Skottland |
| Wales | Wales | Wales | Wales | Wales | Wales |
| Ireland | Irland | Ierland | Irland | Irland | Irland |
| France | Frankreich | Frankrijk | Frankrig | Frankrike | Frankrike |
| Belgium | Belgien | België | Belgien | Belgien | Belgien |
| Italy | Italien | Italië | Italien | Italia | Italien |
| Spain | Spanien | Spanje | Spanien | Spania | Spanien |
| Portugal | Portugal | Portugal | Portugal | Portugal | Portugal |
| Romania | Rumänien | Roemenië | Rumænien | Rumenia | Rumänien |
| Germany | Deutschland | Duitschland | Tyskland | Tyskland | Tyskland |
| Austria | Österreich | Oostenrijk | Østerrig | Østerrike | Österrike |
| Switzerland | Schweiz | Zwitserland | Schweiz | Schweiz | Schweiz |
| Netherlands | die Niederlande | de Nederlanden | Nederlandene | Nederlandene | Nederländerna |
| Holland | Holland | Holland | Holland | Holland | Holland |
| Denmark | Dänemark | Denemark | Danmark | Danmark | Danmark |
| Norway | Norwegen | Noorwegen | Norge | Norge | Norge |
| Sweden | Schweden | Zweden | Sverige | Sverige | Sverige |
| Finland | Finnland | Finland | Finland | Finland | Finland |
| Estonia | Estland | Estland | Estland | Estland | Estland |
| Latvia | Lettland | Letland | Letland | Lettland | Lettland |
| Lithuania | Litauen | Lithauen | Litauen | Litauen | Litauen |
| Hungary | Ungarn | Hongarije | Ungarn | Ungarn | Ungern |
| Poland | Polen | Polen | Polen | Polen | Polen |
| Czecho-slovakia | Tschecho-slowakei | Tsjecho-slowakije | Czecho-slovakiet | Tsjekko-slovakiet | Tjecko-Slovakiet |
| Yugoslavia | Südslawien | Joego-Slavië | Jugoslavien | Jugoslavia | Jugoslavien |
| Russia | Russland | Rusland | Rusland | Rusland | Ryssland |
| Bulgaria | Bulgarien | Bulgarije | Bulgarien | Bulgaria | Bulgarien |
| Greece | Griechen-land | Griekenland | Grækenland | Hellas | Grekland |
| Turkey | Türkei | Turkije | Tyrkiet | Tyrkiet | Turkiet |
| Persia | Persien | Perzië | Persien | Persien | Persien |

| | *Magyar* | *Finnish* | *Estonian* | *Latvian* | *Lithuanian* |
|---|---|---|---|---|---|
| Great Britain | Nagy-britannia | Iso-Britannia | Suur-Briti | Liel-britānija | Didžioji Britanija |
| England | Anglia | Englanti | Inglismaa | Anglija | Anglija |
| Scotland | Skócia | Skotlanti | Sotimaa | Skotija | Škotija |
| Wales | Wales | Wales | Wales | Uelsa | Valija |
| Ireland | Irország | Irlanti | Iiri | Īrija | Airija |
| France | Francia-ország | Ranska | Prantsusmaa | Francija | Prancūzija |
| Belgium | Belgaország Belgium | Belgia | Belgia | Beļģija | Belgija |
| Italy | Olaszország Itália | Italia | Itaalia | Itālija | Italija |
| Spain | Spanyol-ország | Espanja | Hispaania | Spanija | Ispanija |
| Portugal | Portugália | Portugali | Portugal | Portugalē | Portugalija |
| Romania | Románia | Romania | Rumeenia | Rumānija | Rumunija |
| Germany | Németország | Saksa | Saksamaa | Vācija | Vokietija |
| Austria | Ausztria Osztrák-ország | Itävalta | Austria | Austrija | Austrija |
| Switzerland | Svájc | Sveitsi | Helveetsia | Šveice | Šveicarija |
| Netherlands | Német-alföld | Alankomaat | — | — | — |
| Holland | Hollandia | Hollanti | Hollandi | Holande | Olandija |
| Denmark | Dánia Dánország | Tanska | Daani | Dānija | Danija |
| Norway | Norvégia | Norja | Norra | Norvēģija | Norvegija |
| Sweden | Svédország | Ruotsi | Rootsi | Zviedrija | Švedija |
| Finland | Finnország | Suomi | Soome | Somija | Suomija |
| Estonia | Észtország | Viro | Eesti | Igaunija | Estija |
| Latvia | Lettország | Latvia | Läti | Latvija | Latvija |
| Lithuania | Litvánia | Liettua | Leedu | Lietava | Lietuva |
| Hungary | Magyar-ország | Unkari | Ungari | Ungārija | Vengrija |
| Poland | Lengyel-ország | Puolo | Poola | Polija | Lenkija |
| Czecho-slovakia | Cseh-Szlovákia | Tshekko-Slovakia | Tschekko-slovakkia | Čeko-slovāķija | Ceko-slovakija |
| Yugoslavia | Jugoszlávia | Jugoslavia | Jugoslaavia | Jugoslāvija | Jugoslavija |
| Russia | Oroszország | Venäjä | Venemaa | Krievija | Rusija |
| Bulgaria | Bulgária | Bulgaria | Bulgaria | Bulgārija | Bulgarija |
| Greece | Görögország | Kreikka | Kreeka | Grieķija | Graikija |
| Turkey | Törökország | Turkki | Türgi | Turcija | Turkija |
| Persia | Perzsia Perzsaország | Persia | Persia | Persija | Persija |

| | *Polish* | *Czech* | *Serbo-Croat* | *Turkish* |
|---|---|---|---|---|
| Great Britain | Wielka Brytanja | Velká Britanie | Velika Britanija | Büyük Britanya |
| England | Anglja | Anglicko | Engleska | İngiltere |
| Scotland | Szkocja | Škotsko | Škotska | İskoçya |
| Wales | Walia | Wales | Vels | Gal Memleketi |
| Ireland | Irlandja | Irsko | Irska | İrlanda |
| France | Francja | Francie | Francuska | Fransa |
| Belgium | Belgja | Belgie | Belgija | Belçika |
| Italy | Włochy | Italie<br>Vlachy | Italija | İtalya |
| Spain | Hiszpanja | Španěly<br>Španělsko | Španija | İspanya |
| Portugal | Portugalja | Portugalsko | Portugalska | Portekiz |
| Romania | Rumunja | Rumunsko | Rumunija | Romanya |
| Germany | Niemcy | Německo | Nemačka | Almanya |
| Austria | Austrja | Rakousko | Austrija | Avusturya |
| Switzerland | Szwajcarja | Švýcarsko | Švajcarska | İsviçre |
| Netherlands | Niderlandy | Nizozemsko | Nizozemska | Felemenk |
| Holland | Holandja | Holandsko | Holandija | Holanda |
| Denmark | Danija | Dánsko | Danska | Danimarka |
| Norway | Norwegja | Norsko<br>Norvéžsko | Norveška | Norveç |
| Sweden | Szwecja | Švédsko | Švedska | Isveç |
| Finland | Finlandja | Finsko | Finska | Finlandya |
| Estonia | Estonja | Estonsko | Estonska | Estonya |
| Latvia | Łotwa | Lotyšsko | Letonska | Letonya |
| Lithuania | Litwa | Litva | Litvanija | Lituvanya |
| Hungary | Węgry | Mad'arsko<br>Uhry | Madžarska | Macaristan |
| Poland | Polska | Polsko | Poljska | Polonya<br>Lehistan |
| Czecho-slovakia | Czecho-słowacja | Česko-slovensko | Čehoslovacka | Çekoslovakya |
| Yugoslavia | Jugosławja | Jugoslavie | Jugoslavija | Yugoslavya |
| Russia | Rosja | Rusko *or* Rus | Rusija | Rusya |
| Bulgaria | Bułgarja | Bulharsko | Bugarska | Bulgaristan |
| Greece | Grecja | Řecko | Grčka | Yunanistan |
| Turkey | Turcja | Turecko | Turska | Türkiye |
| Persia | Persja | Persie | Persija | İran |

## NAMES IN GREENLAND

THE course of discovery in Greenland, especially in East Greenland, makes it natural that the names used in early days by explorers should be in several European languages as well as in the native Eskimo; that some of the European names should have become altered by translation; that there should be rival names for important features; and that in short there should have been a good deal of confusion in the past which it will fall to the Danish authorities to disentangle and to remedy now that their ownership of the whole of Greenland has been established.

The Secretary some weeks ago addressed to the Director of the Geodetic Institute at Copenhagen an inquiry on the matter, asking who would be the final authority for names in Greenland; whether the names on the maps published by the Geodetic Institute should be taken as fully considered and finally adopted; what is the proper procedure for a traveller who wishes to write about a feature which has not hitherto been named; and to what authority should proposals for new names be submitted. Recent practice of the *Journal* has been to put upon a map, say of the Antarctic, "New names on this map are those proposed by . . .", which is convenient in liberating the name at once for the author in the text accompanying the map and at the same time treating the name as nothing more than a provisional label and subject to the approval of the competent authority. Would this method be suitable for a paper on a journey in Greenland published by our Society in case the author wished to suggest certain names?

To these inquiries Professor Nørlund, the Director of the Geodetic Institute, has replied that the final authority for new names in Greenland is a Committee recently nominated by the Danish Government, of which the Director of the Greenland Administration and the Director of the Geodetic Institute are members. The names upon the Geodetic Institute maps of the west coast have been adopted by the Committee, and the names on all future maps published by the Geodetic Institute will be considered before publication and adopted, so that they can be recorded as final.

The Director considers it very desirable that a traveller who wishes to propose new names should submit his proposals to the Committee. The Danish Government has officially informed the British and other Governments that no new names in Greenland will be recognized by the Danish Government unless they have been approved individually by the Committee. Several expeditions which have recently worked in Greenland have already proposed to the Committee new names which have been adopted, and the Greenland Administration now always informs the leader of an expedition going to Greenland that if he wishes to propose new names the suggestion must be forwarded to the Committee at the address: Statsministeriet, Copenhagen.

On the question of the present practice of this *Journal* dealing with new names as described above, the Director replies that he would regard it as a great advantage if in general authors should use only names which have been adopted, though the alternative course can always be pursued. It does however cause considerable trouble if new names are published even thus tentatively which cannot always be sanctioned by the Committee. We shall there-

fore avoid using any such names, though there must be cases such as that of a conspicuous feature seen from the air and not fixed with precision in which some temporary name may be required by the narrative of events.

The following is a schedule of the maps of Greenland published by the Geodetic Institute which may be taken as the final authority for names:

1. Kort over Grønland. Scale 1 : 250,000. Copenhagen: Geodætisk Institut, 1932. Sheets: 1, Godhavn; 2, Christianshaab; 3, Jakobshavn.
2. Map of North Greenland. Scale 1 : 300,000. Surveyed by Lauge Koch in the years 1917–23. Published by the Geodetic Institute of Denmark, 1932. 19 sheets.
3. Østgrønland mellem 70° og 77° n. Br. Efter de nyeste Kilder, deri indbefattet Opmaalinger og Rekognosceringer udført af Lauge Koch 1932. Scale 1 : 1,000,000. Copenhagen: Geodætisk Institut, 1932.

The official notice which was communicated to foreign Governments a year ago, but not to our Society or to the Permanent Committee on Geographical Names for British Official Use, reads as follows:

NOTICE REGARDING THE APPOINTMENT OF A TOPOGRAPHICAL NAME COMMITTEE FOR GREENLAND AND NAME-GIVING OF GREENLAND LOCALITIES

As it is known to the Danish Government that different expeditions have given names to localities in Greenland and used the names thus given in the treatises and charts published by them, the Ministry of State hereby make known that a Subcommittee has been set up within the Committee for scientific investigations in Greenland, such Subcommittee being authorized to take decisions with regard to Greenland topographical names, and that names given to localities within Greenland territory will not be recognized by the Danish State unless such name in each case be sanctioned by the Topographical Name Committee.

In case such recognition be desired, suggestions accompanied by possible necessary particulars must be forwarded to the Committee under the address: Statsministeriet, Copenhagen.

*Ministry of State,*
*Copenhagen, February* 1, 1934.

## GEODESY IN BALTIC COUNTRIES

VERHANDLUNG DER IN WARSCHAU VOM 14 BIS 18 JUNI 1932 abgehalten sechsten Tagung der Baltischen Geodätischen Kommission. Redigiert vom Generalsekretar ILMARI BONSDORFF. *Helsinki* 1933. 226 *pages and* 8 *charts*

BALTISCHE GEODÄTISCHE KOMMISSION. Bestimmung der Längenunterschiede der Landeszentralen in Jahre 1929. I. Sonderveröffentlichung No. 2. Das Beobachtungsmaterial. *Helsinki* 1932. 229 *pages*. II. Sonderveröffentlichung No. 3. Die Berechnung der Längendifferenzen des Landeszentralen, von F. PAVEL. 49 *pages*. Ditto, von ILMARI BONSDORFF. 91 *pages*

VERÖFFENTLICHUNGEN DES FINNISCHEN GEODÄTISCHEN Institutes No. 18. Beobachtungsergebnisse. *Helsinki* 1933. 240 *pages and chart*

VERÖFFENTLICHUNGEN DES FINNISCHEN GEODÄTISCHEN Institutes No. 20. Die Länge der Versuchsbasis von Helsinki und Längenveränderungen der Invardrähte 634–637, von ILMARI BONSDORFF. *Helsinki* 1934. 41 *pages*

DURING the last fifteen years a grand attack on the problems of geodesy has been launched by the countries which surround the Baltic. Conspicuous among these is Finland. Since 1923 the Geodetic Institute of that country has issued twenty special publications, dealing with principal triangulation, gravity, isostasy and the figure of the Earth, which represent much new and particularly high-class field work as well as theoretical discussions of world-wide interest. The successful prosecution of geodetic work calls for extension beyond national borders and so international co-operation is essential.

The International Union of Geodesy and Geophysics, which replaced the International Geodetic Association brought to an untimely end by the world war, held its first meeting at Rome in 1922, and has since met on four occasions It may well have been found by these active Baltic countries that closer and more frequent mutual consultation than was provided by the International Union was desirable; at all events, in 1924 took place at Helsinki the inaugural meeting of the Baltic Geodetic Commission. Since then there have been meetings in 1926, 1927, 1928, 1930, and 1932. The adhering countries now comprise Denmark, Estonia, Finland, Germany, Latvia, Poland, Sweden, and U.S.S.R., the latter joining in 1929. The president of the B.G.K. is Professor E. Kohlschutter (Germany) and the general secretary Professor I. Bonsdorff (Finland).

At the sixth meeting of the B.G.K. at Warsaw in June 1932 Professor Kohlschutter was prevented by illness from attending, and the chair was occupied by Professor Nørlund. Mon. J. Jedrzejewicz, Polish Minister of Public Instruction and Culture, in welcoming the delegates referred to the goodwill engendered by the collaboration of countries in scientific work, so desirable for the stabilization of peaceful conditions. In his response Professor Nørlund referred with pride to the work accomplished by the Commission since its inauguration in 1924. That this pride is well founded is proved by the present publications. Through the collaboration of the countries grouped round the Baltic the common aims of the whole region have been advanced as though there were but a single control. Geodetic work knows no boundaries and cannot be carried to full success if restricted to small areas, independently treated. That such collaboration need not swamp the individuality of the separate countries is here evident, and it is striking that worthy contributions come from all. So much is this the case that it is impossible to do justice to each and every one in a review of reasonable length.

At the opening ceremony, Professor Banachiewicz, the principal Polish delegate, delivered an interesting address on "Les problèmes et les méthodes de la géodésie supérieure." Here Boscovic, a Slav scientist of the eighteenth century, is mentioned as the first to picture vaguely the existence of compensation at a certain depth. Professor Banachiewicz remarks later "we learn that the solid part of the Earth, that which is capable of sustaining a load, does not reach a depth of more than 100 km.; from there begin the plastic or fluid layers resulting from the high temperatures." A little farther on he mentions the remarkable result, attributed to Helmert, that the Earth's equator is elliptic, and regarding this he truly says "Il n'est pas facile de bien comprendre ceci et c'est là une véritable énigme de la géodésie contemporaine." The elliptic equator, if substantiated, negatives the plastic or liquid condition just contemplated at depths greater than 100 km. Evidence both of triangulation arcs and gravity suggests its reality. In 1860 the British geodesist, Clarke, found from a discussion of

triangulation arcs a difference of equatorial semi-axes of 465 metres with major axis in longitude 15°·6 E. Helmert in 1915, from gravity results, found as corresponding figures 200 metres and 17° W.; and in 1924 Heiskanen derived, from much fuller gravity data, 345 metres and 18° E.—which are closer to Clarke's values than Helmert's. However even now the reality of the results is in doubt.

For the connection of the precise levelling between Denmark and Sweden across the Danish Sound, some 3 miles wide, Professor Nørlund stated that simultaneous observations would be made from two high towers at Helsingör and Helsingborg and that the desired accuracy was 0·5 cm.; and Professor Rosen added that additional observations would be taken from the mid-point on the ice. It will be interesting to hear more of this connection.

The national reports show continued activity. One is astounded at the vastness of the reported work of the U.S.S.R., both accomplished and to be done in the near future; and triangulation extending to the east coast of Asia and ultimate connection with America seem to be well in the picture. Laplace points abound. Extension to connect the great Indian Survey does not seem to be contemplated as yet; but as this latter has already been joined with the old Russian work in the Pamirs we may hope for the accomplishment of this long-desired Indo-European through-connection. The junction of the Danish and German triangulation is referred to in Professor Seidel's report of Germany's geodetic work in 1931, 1932. For this, special observation structures were necessary, the greatest being at Staberdorf, where observer height was 35 m. and signal height 62 m. The resulting angular measures are discussed and their derived error compared with corresponding values for other German series, showing that the general level of accuracy is maintained.

Professor Bonsdorff reports the conclusion of the great S. Finnish quadrilateral, unique in its 93 stations all Laplace points. The circuit length is 1250 km. and there are 5 base-lines. The adjustment of this work is described by V. R. Olander. The large number of Laplace controls makes this a heavy piece of work. Much triangulation of the nineteenth century was adjusted with no Laplace controls and not many additional bases; and one felt that the optimum results would occur when bases and Laplace controls were equally numerous. But Finland has gone far beyond that. The total number of gravity stations in Finland was 127 in 1932. These have been used to determine the anomalies of density in the crust, assumed to lie within 20 km. of the surface; and the geoidal form in relation to the reference spheroid was then derived and compared with the results of the plumb-line deviations, with satisfactory accordance. The work seems to have followed lines originated in India and applied there some years earlier. Professor Bonsdorff considers that the results of deviations in Finland and mid-Europe indicate a larger semi-axis of the Earth than that of the adopted International spheroid.

There are interesting and important mathematical developments represented by two contributions; one, by Burrau (Denmark) on a simplified form of computation of latitude and longitude from triangulation, in which however the degree of approximation is somewhat obscure; the second by Grabowski (Poland) on the equation of the orthodrome (geodesic line). The latter states that after completing his work he found himself in part forestalled by Halphen. It is of increasing difficulty for individuals to find out what has already been accomplished or even to get access to it if known. In this case at least there is benefit in the work now being readily available for geodesists; for, as the author says, the geodesic is the only three-dimensional curve of interest to geodesists.

Of great interest and apparently of equal promise is the Static Gravity-meter, described by G. Nörgaard, who is presumably also the inventor. In this the

weight of a column of mercury is balanced against the pressure of an enclosed volume of air. Variations of gravity accordingly cause variations of the air volume. The whole glass system containing the air and mercury, with a small diameter tubular extension, is made to float in a long cylinder containing paraffin; the extension, which can also be loaded suitably, protruding more or less above the paraffin surface. Measurement of the amount of the protrusion gives a determination of "g"; and in the experimental model 1 milligal is equivalent to 0·05 protrusion. The system is mostly compensated for temperature changes, and a change of temperature of 1° corresponds to a change in "g" of 3 milligals. With this system of flotation many of the older difficulties seem to disappear, and we have promise of a very practical instrument of moderate size (length 94 cm., diameter 6·3 cm.), and weight (4·2 kg.), from which gravity may be read off with extreme rapidity. The comparison of a set of determinations in Jutland with results of pendulum observations was, in 1932, awaiting the reduction of the latter. No remarks are made as to any special precautions required for the safe transport of the instrument, but journeys by car and rail as well as in rucksack have been successfully performed.

The Baltic Geodetic Commission recognized in 1927 the need for accurate determinations of the longitudes of each national origin of survey and a well-planned project was actually carried through in 1929. The observing period was divided into three parts and each observer occupied his home station for the first and third parts and the anti-clockwise adjacent station for the second part. The observers and their home stations were: Pavel/Potsdam (Berlin), Andruszewski and Witkowski/Posen (Poland), Slaucitajs/Riga (Latvia), Livlander/Tallinn (Estonia), Dneprowsky/Poulkovo (Leningrad), Leinberg/Helsinki (Finland), Aurell/Lovo (Stockholm), Johannsen/Buddinge (Copenhagen). Professor Kohlschutter exercised a general supervision.

The partial interchange of observers allowed personal equations to be determined. Indeed, the Danish observer worked for one evening at Copenhagen with the Swedish observer, while on another occasion at Potsdam he observed with Dr. Muhlig for the independent determination of personal equation; but it is not clear how this latter was useful as the usual German observer was H. Pavel. It appears that on these occasions the foreign transits were taken to Copenhagen and Potsdam respectively; but otherwise it does not seem clear whether the observers took their own instruments for observations at foreign stations in the second period; and the present writer infers that they did not do so.

Generally the transit instruments were by Bamberg. The master clocks were of varying quality. At Posen there was a Shortt clock; at Potsdam two Dencker clocks, while at Riga and Pulkovo were Riefler clocks. The Copenhagen clock was by Max-Richter; Stockholm, Tallinn and Helsinki had Strasse and Rohde clocks, all of which, and particularly that at Helsinki, displayed relatively large variations of daily rate. The equipment and observations at each station are described in interesting accounts written by the observers. Weather conditions are not much referred to, but at Helsinki great difficulties were experienced on account of damp, which frequently obscured the transit object-glass and also interfered with the wireless equipment.

Long-wave time signals were received from Bordeaux, Paris, and Nauen by registration and also, except at Copenhagen, by aural means. This latter, which the present writer gathers was a coincidence method, is referred to under the rather formidable series of names Cook, Hanni, Leinberg, Preipitsch; and one wonders who is the veritable originator. The Danish observer, J. Johannsen, remarks "since there is no systematic difference between the registration method

and the aural method, the signals were received only by registration." This view is not held by Professor Bonsdorff who, in the subsequent discussion, finds a systematic difference aural–registered = − 24 millisecs.

The observations are separately discussed by Herr Pavel and Professor Bonsdorff, who reach slightly different results—the greatest variation being 15 millisecs for longitude difference Tallinn–Riga. Dr. Pavel explains that star R.As. were reduced by Dr. Renz to system Pulkovo, 1915. Both he and Professor Bonsdorff correct for polar migration, but use for the rate of propagation of the wireless waves $3 \cdot 10^5$ km./s. and $2 \cdot 43 \cdot 10^5$ km./s. respectively. Pavel finds values of mean error of a star passage varying between 23 and 51 millisecs for different observers. Owing to apparent jumps in personal equation he takes out results on three suppositions: (*a*) Errors only accidental; (*b*) jump by Witkowski; (*c*) jumps by Witkowski, Johannsen, and Livlander. A comparison with old values of arc Pulkovo–Potsdam favours (*c*) and the jumps are considered real. The application of matrix-calculus to the solution of the normal equations is explained, though not in enough detail for any one not already familiar with matrices. Detailed tables of residual errors of individual evenings on the three suppositions (*a*), (*b*), (*c*) are given, and the average greatest error of stations is 43 ms. The absolute greatest is at Helsinki of 63 ms., which seems attributable to the rather imperfect clock at that place.

Pavel supports the decision of the B.G.K. to reject nb observations and shows that such rejections do not affect appreciably the final values of longitude. On the other hand, Bonsdorff explains in his foreword that the four widest observations, which deviated from the mean of the rest of the evening by amounts ranging between 163 and 219 ms., have been rejected by him. He mentions that many stars have been observed in the longitude work from 40 to 160 times, and proceeds to determine their R.As. with a greater weight than the catalogue (Renz) values. He finds however that the use of these improved values has little appreciable effect on the final longitude values. The chain method of longitude observation is held to be well justified, and from observations on about thirty evenings per station neighbouring stations are fixed with a mean error of 7 ms., and absolute longitudes with a mean error of 10 ms.—sufficiently precise in consideration of the high latitude.

A very practical result derived from considerations of the errors is that it is useless to extend the observations of an evening beyond sixteen stars, as increase to twenty-four stars only increases the evening weight by 10 per cent. A systematic difference between aural and automatic reception is determined at from 20 to 30 ms., and strangely it is the aural reception which gives longitudes according better with the old determination of Pulkovo–Potsdam. Professor Bonsdorff has an uncanny skill in separating out errors of different types, and his discussion is valuable in showing what is significant. To the present writer, who has experienced serious and as yet unexplained differences between two instruments at practically identical sites, there appears only one criticism, that *instrumental* differences have not been considered, unless indeed these are included with the observers' personal equations. The whole work has been carried out in an exemplary manner both as regards observation and then as regards discussion. Professor Kohlschutter's work of co-ordinating the whole has been very successful.

Turning now to the purely Finnish publications, we find in the first a bare record of a great mass of first-class geodetic work. As regards principal triangulation it covers the two summer seasons 1930, 1931, in which twenty-seven principal stations were occupied and the angular measures of the great S. Finnish quadrilateral were completed. The observations were usually spread over three

or four days and were to both helios and lamps in roughly equal proportion. In all cases observing scaffolds and elevated signals were necessary and in many cases forest lines had to be cleared. So in addition to the main angular work there was the considerable extra detail of determining the relative positions of station mark, instrument, and signal. It has also to be remembered that astronomical observations for azimuth, latitude, and longitude were made at each and every station; so that the Finnish quadrilateral of a total periphery of 1250 km. sets a completely new standard for geodetic operations. One minor feature of the records—estimates of quality of signal on a scale from 1 (good) to 6 (bad)—indicates that the observers had often to compete with bad visibility. The prompt completion of the work in which a high standard of accuracy was attained is accordingly a very creditable performance.

On glancing at the abstracts one finds that the variations of the values of an angle on the 12 zeros only occasionally reached 3″ and that the greatest triangular error was 1″.17. As regards heights, spirit-levelled connections were made at four stations of these last twenty-seven and the rest were found from vertical angles, of which no details are given. In view of the fact that plumb-line deviation in both co-ordinates were determined at all the ninety odd stations of the quadrilateral, the vertical angle data must form a most valuable basis for the discussion of vertical refraction. In most triangulation vertical angles are burdened with deviation of the vertical anomalies, so that a comparison of reciprocal angles gives a mixture of refraction and deviation effects, from which the refraction cannot be separated; but here this difficulty is absent and it will be a pity if the refraction is not analysed. No doubt, seeing that both instrument and signal had always to be raised considerably above ground-level, the rays passed close to the ground; and on this account the refraction may often be abnormal. It will be none the less interesting on that account, and its discussion by the capable officers of the Finnish Geodetic Institute would lead to valuable results. The base measured at Ilmajoki of length about 6 km. showed a mean error of 1 in 8 million, and the greatest triangular error of the base extension figure was 0″.73.

Particulars of azimuths observed at sixty-two stations during 1926, 1927, 1930, 1931, are given, as also details of latitude and longitude at twenty-five stations observed in 1931. Thus such observations have now been made at all the stations of the great quadrilateral. The mean errors derived for these three types of observation were for azimuth from $\pm 0''.32 \tan \phi$ to $\pm 0''.17 \tan \phi$, for latitude $\pm 0''.152$, and for longitude difference from Helsinki $\pm 0''.42$—all indicating first-class accuracy, both personal and instrumental.

An experimental base of length 720 m. has been the object of numerous comparisons during the years 1923–1933. It is located on the island of Santahamina not far distant from Helsinki and originally offered ideal conditions for measurements. The surface is sand overlying a granite layer and, while the north mark-stone is a large granite block embedded in the sand, the south mark is on natural rock. The direction is north and south, cut through a low pine forest which offered protection from wind and sun. Unfortunately the island has latterly been employed as a military aerodrome and the trees have been cut; and, although the base will remain of use for some years, it has been necessary to make provision for the future by selecting another base-line, of length 864 m., in the neighbourhood of Nummela some 50 km. from Helsinki. It is regrettable that the Santahamina base will have to be abandoned finally considering how much labour has been expended on its standardization.

The Santahamina base has been used as a standard base since 1923 both by Finland and some other countries. Through various standardizations of wires

it has been compared on no less than thirteen occasions with the standards of several countries, as follows: Breteuil (thrice), Warsaw (twice), Helsinki (four times), Charlottenburg (twice), Copenhagen (once), and Moscow (once). As seems inevitable in such cases some discrepancies have arisen, and these are discussed by Professor Bonsdorff in special publication No. 20. One side result is a relation between the standards of England, France and Germany, exhibited by the following differences: Teddington–Breteuil $+2{\cdot}0\,\mu$, Charlottenburg-Teddington $-0{\cdot}1\,\mu$; and it will be interesting to know if these results are confirmed independently.

From the maze of numerous comparisons Professor Bonsdorff, with much diligence and skill, unravels several types of variation of wire length. In addition to the well-known secular change of invar he finds also the results of repeated suspensions of the wire when in operation and of its unwinding and re-winding on its drum in the intervening periods. His results are—

T = secular change $= 12\mu$ per annum
S = change due to suspension $= -4{\cdot}0\mu \pm 1{\cdot}9\mu$ (unit 100 suspensions)
R = change due to winding $= 4{\cdot}2\mu \pm 1{\cdot}3\mu$ (unit one winding and unwinding).

The following conclusions are reached: (1) When the wires, carefully handled both before and after field use, are compared at the experimental base, the mean errors of wire length are about 1 in 2 million. (2) Although the determinations of the suspension and winding variations of length are not very secure yet, in Professor Bonsdorff's opinion, they ought to be used for the reduction of base measurements.

From what has been said it should be very clear that geodetic work is at present very vigorous in Baltic regions and that it is also of a very high quality; and further that new methods, instrumental and other, are being investigated with success. The outlook of the Baltic Geodetic Commission is very wide and by no means confined to the regions surrounding the Baltic. The work accomplished sets a very high standard from which lessons may be learned by older and larger geodetic departments in other parts of the world. It is surprising that these relatively small Baltic countries should have developed much of this activity during the times of uncertainty which have followed the world war—a time during which larger and wealthier countries have deemed it advisable to restrict activities in such directions. Geodesy may appear of only academic interest to some minds; but it provides the only sure foundation to a system of maps and to international boundaries; and any country which thinks it possible to get on without a well-founded map system will pay dearly in many ways for its lack of foresight and understanding. The day is approaching when a complete gravity survey will be found to be essential for the proper development of the mineral resources of a country, and some thanks may then be given to those who have striven to make gravity measurements and to those who have developed or invented instruments whereby gravity may be measured. In several divisions of geodesy the Baltic Geodetic Commission and its component countries are playing a conspicuous part, which should earn the gratitude of all civilized people. May they long continue to do so with undiminished success!

J. DE GRAAFF HUNTER

# REVIEWS

## EUROPE

ALONG THE ROMAN ROADS. By G. M. BOUMPHREY. *London: George Allen and Unwin* 1935. $7\frac{1}{2} \times 4\frac{1}{2}$ *inches;* 150 *pages; illustrations and map.* 4*s* 6*d*

The author has admirably achieved his object: to describe lightly and for the comparatively unlearned a walk over some of the Roman roads of Britain, and presumably to encourage others to enjoy the fascinating sport of following a noble and purposeful trail *sub divo*. Much may be seen and pondered by the way—how town was (and is) related to town, how armies advanced with commerce in their wake; and there is the added thrill of picking up in some wood the track lost under the plough. Though the author does not claim to be historian or archaeologist, his slight sketches of Romano-British history which form a setting to the walks are well proportioned and commendably accurate. He obviously enjoyed his rambling, and with much gusto conveys his pleasure to his readers, as he had done to his radio listeners. His itinerary includes the Roman routes from Silchester to Axminster, thence the Fosse Way to Lincoln, the Icknield Way from Royston and along the Ridgeway, thence to Cirencester and Caerleon, and so through West Wales by the Sarn Helen to Chester; finally Ermine Street from Lincoln to Royston, and the military road along Hadrian's Wall. When the book is reprinted some place-names should be given correctly: *e.g.* for Bennones (High Cross), Venonae; for Vernometum, Verometum; for Durobriviae, Durobrivae. Lincoln was not "our first Roman colonia"; Colchester was established a quarter of a century before. The Fosse Way is said to be "practically dead straight"; but within the limits (6 miles) of its deflections it is one of the most sinuous Roman roads in England. "Street" as a place-name cannot give assurance that a Roman road was there; 2 miles of a deep-worn cutting on the Fosse need not be fantastically assigned to smugglers; and the association of "wich" with Saltways is purely fortuitous. The Seaton tile is not "the only trace of Legio II before Caerleon": in Nero's reign they are seen to be connected with Mendip lead-mining. Some B.B.C. superlatives might be mitigated.

S. E. W.

ENGLISH VILLAGES AND HAMLETS. By HUMPHREY PAKINGTON. *London: B. T. Batsford* 1934. 9×5 *inches;* viii+120 *pages; illustrations from drawings by* SYDNEY R. JONES *and from photographs by* WILL F. TAYLOR *and others; sketch-maps inside cover.* 7*s* 6*d*

Once again Messrs. Batsford have found a peg on which to hang their beautiful illustrations, though it is less than three years since they published a very similar production entitled 'The Villages of England' (noticed in *Geogr. J.*, vol. 80, p. 447). They were fortunate then in their author for the letterpress, Mr. A. K. Wickham, and they are equally fortunate in the present writer. Mr Humphrey Pakington has an architect's eye for good compositions, and furthermore, one that twinkles with humour, especially when it sees a signpost pointing to places with almost unbelievable names. He amuses himself with selecting an English village XV and then is impelled to go on and select a second XV; like most selectors he expects to satisfy no one. Those rare villages whose layout was deliberately planned, such as Lowther and Milton Abbas, make a strong appeal to him, and he finds curious affinities between villages in distant parts of the country. He considers a possible classification according to arrangement of the site: (1) round a green, (2) along a road, (3) at a dead end, (4) on down or

moor, (5) on a hill-top, (6) at a riverside; but ultimately he has to fall back on much the same semi-geological divisions as Mr. Wickham's—home counties, the south-west, East Anglia, the stone-belt, red-brick and black-and-white, the north. He ends with a county list of notable villages illustrated or mentioned; it makes a Middle Saxon sad to find that his poor little county is the Cinderella uninvited to grace this splendid company and causes him to sigh for a magic wand to bring back Edgware, Pinner, and others, as they were within living memory. But the Middlesex village is like the unhappy spot in Mr. E. V. Knox's foreword: "a herd of wild bungalows had trampled it down; it had been savaged by an arterial road and devastated by petrol pumps." Perhaps enough publicity has now been given to the villages and hamlets of England. J. H. R.

## ASIA

A RECONNAISSANCE GEOGRAPHY OF JAPAN. By GLENN THOMAS TREWARTHA. Madison: University of Wisconsin (Studies in the Social Sciences and History, No. 22). 1934. $9\frac{1}{2} \times 6$ *inches;* 284 *pages; illustrations and maps.* $2.00

This volume, which is No. 22 in the University of Wisconsin Studies in the Social Sciences and History, contains a lot of useful information not readily accessible to foreign readers. Much of the language, it is true, is technical, but in parts the book consists of a simple description of scenery and living conditions in Japan proper. Every page bears testimony to the care and thoroughness with which the author has set about his work, and the footnotes show that he has made the fullest use of Japanese sources in compiling his material. This making public of the work of Japanese scientists gives the book an added value. Two features call for special mention: (1) the use made of the excellent topographical maps published by the Japanese General Staff, maps which, as the reviewer knows well, in quality and accuracy hold their own with those of any country and in price are the envy of all foreign cartographers—a good map in three colours costs $3\frac{1}{2}d.$! and (2) the selection of pictures at the end of the volume, which gives an accurate idea of ordinary Japanese scenery as distinct from the special pictures which abound in volumes of travel. The author is to be congratulated on the choice he has made.

The value of the book however is greatly reduced by some serious omissions. There is no index at all: even the list of contents is of the briefest. Furthermore, while the smaller maps are of use in illustrating physical features and the like, inasmuch as they are taken direct from the Japanese official survey, the names are all in Japanese and therefore meaningless to the ordinary reader. Again, though there are many diagrammatic maps, the book lacks a big map containing all the names mentioned in the second half of the volume, which treats of the regional sub-divisions of Japan. As a result, a great deal of the data conveys little, except to those who are familiar with Japan at first hand. We note with pleasure that the author has not adopted the Romazikwai system of spelling, now officially used in Japanese Admiralty charts and military maps, which produces such unfamiliar forms as Huzisan for Fujiyama. He has followed the Hepburn system still wisely used by the Japanese railway and tourist authorities.

On p. 35 a list of communities is given classified according to the 1925 census, which suggests that at that time there were no cities containing a population between 200,000 and 400,000. This does not agree with the map on p. 41, dated 1930. Tokkaido (p. 73) should read Tokaido. The statement on p. 18

that "in Japan there is little difference in temperature between the Pacific and the Japanese Sea coasts" will be read with surprise by those whose lot it has been to reside on the latter. The severity of the climate of the western shores of Japan, exposed to the icy blasts from Siberia, is notorious.

But these faults are small blemishes in what represents a lot of careful and painstaking research. With a good general map and an index the volume would be of real value. W. H. M. W.

A SKETCH OF THE GEOGRAPHY AND GEOLOGY OF THE HIMALAYA Mountains and Tibet. By Colonel S. G. BURRARD and H. H. (later Sir HENRY) HAYDEN. Revised by Colonel Sir SIDNEY BURRARD and A. M. HERON. Second (1932–33) Edition. *Delhi: Government of India* 1933–34. [The geological sections of Parts I, II, and III; and] Part IV. The Geology of the Himalaya. $12\frac{1}{2} \times 9\frac{1}{2}$ *inches;* vi+277—360+xxxii *pages; illustrations and maps*

The original edition of this monograph appeared in 1907–8, the geographical part being the work of Colonel Sir Sidney Burrard and the geological part the work of H. H. Hayden (later Sir Henry Hayden). At that time, although few geologists had worked in the Himalaya compared with the number in the Alps, a stage had been reached when certain generalizations had emerged and a summary was needed. The original work was presented as far as possible in non-technical language, and the monograph has proved invaluable to all Himalayan expeditions since its appearance. Dr. A. M. Heron, of the Geological Survey of India, has had the task of bringing Hayden's work up to date. During the last quarter of a century the problems of Himalayan geology have not been clarified by any great generalizations, so that Heron's task has been to add detail. What is known of the geology of the Himalaya is the work of the Survey of India supplemented, but only to a small extent, by the observations of travellers. The attitude of the Survey as a whole has been to refrain from applying to the Himalaya theories which were made to fit the Western Alps. The mechanism producing the two ranges is certainly somewhat different, and at present it seems wise of the Survey to continue the slow collection of facts with the minimum of theoretical explanations.

The sixty pages of the original edition have been increased to eighty. There are new sections on Tibet and Chitral, the Karakoram, and the Pamirs. Among the new work described is that of Mr. C. S. Middlemiss and Mr. D. N. Wadia in Kashmir and the Western Himalaya, and that of Dr. G. F. Pilgrim and Messrs. W. D. West and J. B. Auden in the Simla district. The latter have proved the existence of flat recumbent folds of great amplitude, which however are probably Archaean in age and have nothing to do with the extensive overthrusting of post Eocene age. The value of contributions made by geologists during expeditions has in some cases been unequally assessed. Professor G. O. Dyhrenfurth's claim that the entire Mesozoic succession is included in the deposits of northern Sikkim and his statement that a true *nappe* has produced inversion on the Jonsong Peak are mentioned, although no satisfactory evidence for either generalization has ever been given. On the other hand, only a minor point is quoted from Mr. N. E. Odell's more careful work which he carried out during the 1924 Mount Everest Expedition and which is substantiated by a map.

Accompanying the monograph are several admirable geological maps of special regions, and one of the whole Himalaya. Considering that the monograph is essentially for those not familiar with the geology of India it is satisfactory to see on the general map that European names of formations have been adopted. The basal map on which the geological information is superimposed is however confused by having roads and rivers indicated by similar lines and by much

irrelevant letterpress. Minor changes in the production of the book do not seem to be improvements. The inset statements of the general contents of the paragraphs of the old edition were preferable, especially as the present headings to sections do not always cover all the matter dealt with. The new method of giving references sometimes splits sentences into disjointed fragments and the dates of the works quoted are often not given.

The present edition suffers from being a composite work, but it seems unnecessary to have allowed certain completely misleading ideas to be presented. For instance the reader is left to believe that the Rev. Osmond Fisher's theory of the origin of mountain ranges stands to-day unmodified. The whole section on the origin of mountain ranges would have been better either entirely re-written or omitted. The present reviewer felt the greatest admiration and affection for the original edition when he carried it through Tibet in 1933 on the way to Mount Everest. Unless Dr. Heron was prepared to rewrite the monograph completely it would perhaps have been preferable to have left the original as a historical document, and to have devised some method of presenting the new material either in different type or as appendices to sections and chapters. To be adversely criticized must be the lot of any attempt to revise and modify a classic paper, but despite this Dr. Heron will receive the thanks of all those who require a summary of Himalayan geology up to 1932 with full references. L. R. W.

## AFRICA

THE SOUTH AFRICANS. By SARAH GERTRUDE MILLIN. New Edition. *London: Constable & Co.* 1934. 8×5 *inches;* x+332 *pages.* 7*s* 6*d*

This admirable study of the communities of South Africa and of their interrelations had already merited, before the appearance of the present edition, the distinction of being one of the most widely read volumes devoted to a region of "the dark continent." First published in 1926, it is now revised and considerably enlarged by the inclusion of reference to the momentous political events of the last few years and to recent trends in the Native policy of the Union Government.

The key-note of the argument is sounded on an early page when Mrs. Millin states the urgent problem of the country as being that of harmonizing the relationships of the very diverse elements within South African society. Throughout there is careful avoidance of prejudice: balance and proportion are always fairly maintained. Indeed the book is remarkable for its impartiality: a quality usually claimed only by those observers of the South African scene who are visitors, not colonists, and are able to consider the formidable problems of race with academic detachment. Moreover, the author's contacts with the country are so intimate that it has not been possible to level against her the criticism that often assails the visitor so daring as to express a considered view of South African society in the light of a wider experience. Mrs. Millin utilizes a powerful dramatic sense with the utmost effect, so that the chapters appear as the acts of an unfinished drama, possibly a tragedy, in which the principal actors—Bantu, Boer, Briton, Cape Coloured, and Indian—are in turn introduced. Prose as vivid as this is rarely written to-day: there are many passages that memory recalls without effort, so graphic is the pen.

Without being as certain of the ultimate fate of White colonization as was Anthony Trollope when he declared his conviction that South Africa would remain a country of Black Men, Mrs. Millin regards with much misgiving the future of the White stock, and this mainly for two reasons. In the first place, the generally harsh treatment of the Bantu, classed as almost subhuman by the majority of their European masters, will not always be tolerated. Secondly, the

increasing numbers of the "Poor Whites" threaten the entire European community with degeneration; and, though not all authorities would agree that the degenerate class already represents over twenty per cent. of the total White population, there will be no dispute regarding the author's presentation of the problem. It will be noted by a geographer that Mrs. Millin, in company with other students of the "Poor White" question, omits the factor of climate from any part in the deterioration of physical and mental calibre. Perhaps in a future edition she may be persuaded to give her views on the South African climate in its relation to health.

One or two points seem to require correction. The term "Bantu" or "Aba-ntu" is not generally applied to the Black Men of Africa (p. 253), but only to those Natives of the central, eastern, and southern regions of the continent whose speech belongs to one or other branches of a single family of languages. The Sudanese and Guinea Negroes are in a different category from both the cultural and ethnic standpoints. Then again, difficulty for the reader arises in the statement (p. 8) that the Bantu "is not a Negro in the sense that the American Black Man is a Negro." This may leave the impression that the Basutos, the Zulus and the rest are not fundamentally negroid, an impression that no ethnologist would encourage. On p. 257 there is a rather strained comparison between the different groups of the Bantu, on the one hand, and the various European nations. The essential link between the Bantu communities, apart from race, is similarity of language, which is certainly not characteristic of European society. Such points as these are however quickly forgotten in the general excellence of the discussion. W. F.

NEGRO SAHARA: von der Guineaküste zum Mittelmeer. By ARNOLD HEIM. *Bern: Hans Huber* 1934. $9^{1}/_{2} \times 6^{1}/_{2}$ *inches;* 160 *pages; illustrations and map.* 9.80 *fr*

Herr Arnold Heim, a much-travelled Swiss geologist, gives an account of his motor journey with a companion from the Ivory Coast to Algiers, by way of Wagadugu in the Haute Volta, Gao on the Niger bend, Kidal, Tamanrasset, and In Salah. The two travellers, having done some gold prospecting in the Lower Ivory Coast, were granted permission by their principals to use the Citroën saloon which had been placed at their disposal to motor home across the northern part of the continent, for the most part by the lesser-known motor tracks. The book is full of interesting geological material and provides a very readable account of the people and places seen by one who is evidently an acute and interested observer. The ethnological notes and some of the sketches on technological points are very valuable. Of particular interest are the notes on the gold trade on the Ivory Coast. The motor journey is principally remarkable for the courage, one might almost say foolhardiness, of two travellers in a single car attempting to cross the Equatorial bush zone and the Sahara. They repeatedly nearly lost their lives by breakdowns, lack of petrol, and constant tyre trouble. One cannot help feeling throughout the desert part of the journey how much safer camel transport is than the petrol motor. North of Kidal they meant to take the north-east route to Tamanrasset, but got on to a scarcely-used track which after 250 km. landed them at the abandoned desert post of Tessalit, whence they only just succeeded in getting back to Kidal.

It is an unfortunate reflection that valuable geological and ethnological material may easily be lost by being scattered through a general travel book. The two hundred photographs are all of high quality: the map is a poor photographic reproduction of the French 1 : 18,500,000 Afrique Nord-Ouest with the route and a few place-names drawn on it. F. R. R.

## NORTH AMERICA

TRADING INTO HUDSON'S BAY: A Narrative of the Visit of Patrick Ashley Cooper, thirtieth Governor of The Hudson's Bay Company, to Labrador, Hudson Strait and Hudson Bay in the year 1934; from the journal of R. H. H. MACAULAY. *Winnipeg: Published by the Hudson's Bay Company* 1934. 11½×8½ *inches;* 108 *pages; illustrations and sketch-map*

For the first time in its long and honourable history the Governor of the Hudson's Bay Company visited during the summer of 1934 the principal H.B.C. fur-trading posts situated on the Labrador coast, in Hudson Strait, and in Hudson Bay. This beautifully printed and illustrated volume records the chief events of Mr. Patrick Ashley Cooper's voyage. To the traders of the North no less than to the Indians and Eskimo the visit of the Governor was an event of singular moment, as indeed it must have been to the Governor himself accompanied by his officials and the traditional piper who in former days accompanied Sir George Simpson, Governor of Rupertsland.

Each post gave its own welcome in its own particular way. Some were shy welcomes, as is the habit in northern communities, but all provided a liberal programme of sports, feasting, the bestowal of gifts and firework and film displays.

To the reader with leanings towards the life and problems of the North this book is at once of interest and significance. It will carry him through the vicissitudes of "The Bay voyage" aboard the good ship *Nascopie*, and it will convey the thought that the problems of the North are being approached with understanding and sympathy. G. B.

## POLAR REGIONS

MID-ICE: the Story of the Wegener Expedition to Greenland. By JOHANNES GEORGI. Translated by F. H. LYON. *London: Kegan Paul, Trench, Trubner & Co.* 1934. 9×5½ *inches;* xiv×248 *pages; illustrations and map.* 12*s* 6*d*

This is the first account to be published in English of the great German expedition which, led by Alfred Wegener, spent most of 1929, 1930, and 1931 in Greenland. Although Wegener's plans were so ambitious and although the scientific work done was of a higher order than any previously attained in Arctic regions, it has received little attention in this country chiefly owing to the lack of a good English account. For a full review however of the German publications, so far as they have appeared, see this *Journal*, vol. 84, pp. 515–522.

The purpose of the expedition was mainly concerned with a scientific examination of the Inland Ice and of the meteorological conditions over it. A preliminary survey was made in the spring and summer of 1929 to find a suitable place for getting equipment up from the west coast. Fifteen glaciers were examined before a suitable one was found and over 500 miles of sledging was done. In the summer of 1930 the main party arrived on the west coast, equipped with twenty-five Iceland ponies, motor sledges, and over 100 tons of supplies, all of which had to be transported up the glacier. At the same time a small party went to the east coast to establish a weather station in Scoresby Sound. The plans included three fixed stations, all in 71° N.; the west coast main base on the edge of the Ice-Cap at a height of 3000 feet, the east coast station, and Mid-Ice in the centre of the Ice-Cap, 250 miles from the base and 9000 feet above sea-level.

The author, Doctor Georgi, was in charge of the Mid-Ice station, where he spent over a year, so that his account is mainly concerned with this part of the expedition. This is just as well, as it would take several books to deal with the whole expedition and Doctor Georgi tells enough about the rest of it to show us

what was being done. Great difficulties were met in getting the loads up on to the Inland Ice which, together with the failure of the motor sledges to overcome the rough going, resulted in the Mid-Ice station being set up with insufficient supplies. For some weeks Doctor Georgi carried on his work alone until a second dog-sledge journey brought him Doctor Sorge and some more supplies. However by this time the motor sledges had been abandoned altogether with the hut and much of the food, fuel, and instruments. Since they only had a summer tent to live in they decided to send back a letter to Wegener with the returning sledge party explaining the position and stating that they would have to start back with hand sledges if supplies had not reached them by October 20. The returning sledgers met Wegener on the way back. He had foreseen the position and was on his way with fifteen sledges, thirteen of which were driven by Greenlanders. Bad weather overtook them, weather such as had never been believed to exist in Greenland but which we know now makes travel on the Ice-Cap practically impossible from October till March. All but one of the Greenlanders turned back, leaving three, Doctor Wegener, Doctor Loewe, and the Greenlander Rasmus, to continue. After an epic struggle of forty days with temperatures down to 65° below zero they arrived at Mid-Ice, but by this time they had dumped all their supplies on the way. Loewe had very badly frost-bitten feet, which made it impossible for him to return. However by this time a cavern had been dug in the snow and it was thought that supplies would just last out the winter, though fuel was very short. On November 1, the day after their arrival, Wegener and Rasmus set off on the return trail. No one will ever know what their journey was like for neither of them was seen alive again. Their comrades at West Station hoped they were wintering at Mid-Ice, so that it was not until the following spring, when the first relief journey reached Mid-Ice, that the truth was known. Later Wegener's body was found buried by his companion half-way home. Apparently he had died of heart failure. Rasmus had taken his diary and gone on, but his body was never found although nearly 2000 miles was covered in searching for him.

Doctor Georgi gives his story in the form of letters to his wife written at varying intervals. These have been left untouched and so give us a very true picture of that grim, monotonous year but avoid the deadly repetition of a pure diary. Although it is a book to be read in small doses, the mental state of the author and his companions is interesting enough in itself. All three were men of high intellect and of sensitive nature. The strain on them all was great, but there seems to have been no breakdown of nerve or friendship, and although, when the author was left alone for a long spell at the end of the time, he admits his nerves to have gone to pieces after the shock of his leader's death, he never seems to have given up any of his work; on the contrary, he was continually adding to it.

Little could be done in the middle of winter besides the routine weather observations, but there was constant anxiety about Loewe, whose toes had to be amputated without proper instruments or anaesthetics. There was also anxiety about the safety of the cavern roof, which threatened to collapse. Temperatures dropped lower, until in February the minimum of −85° F. was reached. As the spring came round more observations were taken. Instruments were made and there seems hardly anything which could have been measured which was left unrecorded. In addition to the complete series of weather observations, balloons were sent up into the upper air and a shaft was sunk 50 feet into the snow for finding its temperature and stratification. It was a good thing that Doctor Georgi was clever with his hands, for he had to make a great many different pieces of apparatus, from dental forceps to lamps and electric thermometers. When the

final relief party came he confesses to having had about enough of it. The constant heavy work of digging and running his apparatus was telling on his strength. Developing his photographs and filling balloons with hydrogen seem to have been particularly trying. On the return journey by motor sledge they met the various other parties who were sounding the ice depth (6000 feet in some places) by seismic explosions, carrying a line of levelling for the 250 miles from the base to Mid-Ice, measuring the cosmic radiation, observing the force of gravity, and so on.

The book is well worth reading to get an idea of this new style of exploration which involves the intensive cult of physical science at fixed stations as opposed to the old method of casual journeys through unknown country. It seems hard that men who had done so much conscientious work should have had to bear the criticism and accusations which have been levelled at them by some who wish to lay on their heads the blame of their leader's death. A. C.

THE FIORD REGION OF EAST GREENLAND. By LOUISE A. BOYD; with contributions by J. HARLEN BRETZ, O. M. MILLER, WALTER A. WOOD, WILLIAM B. DREW, CHARLES B. HITCHCOCK, and JOHN K. WRIGHT. *New York: American Geographical Society* (*Special Publication No.* 18) 1935. 10×6½ *inches;* x+370 *pages; illustrations and map* (*partly in separate case*). $4

Both Miss Louise Boyd's expeditions to East Greenland have made valuable and important discoveries, and it is very appropriate therefore that the results should now have the added advantage of appearing as a separate Special Publication of the American Geographical Society. The book is concerned mainly with the 1933 expedition, but there are numerous references to the author's first visit in 1931, and many of the photographs were taken on the earlier reconnaissance expedition. The field of work ultimately selected was on the north side of the head of Franz Josef Fjord, and lay along the hitherto unexplored Gregory Valley. This line of attack was chosen as it seemed to lead to the so-called Mystery Lakes sighted from the top of Petermann Peak in 1929. Miss Boyd's forecast proved correct and her wise choice of route made it possible for all the various members of her party to carry out their respective programmes more or less according to plan. The work seems to have divided itself into five main sections: the photography, for which Miss Boyd herself was responsible, echo soundings in the fjords, photogrammetic surveys by Mr. O. M. Miller, physiographic studies by Professor J. H. Bretz, and geological work by Mr. N. E. Odell. The results of all except the last are published in the present volume. All have their special value, but most importance attaches probably to Miss Boyd's own results and to Professor Bretz's contribution on the physiography of the East Greenland fjords.

Miss Boyd's photographs, of which there is an almost overwhelming number, constitute a magnificent picture of the Franz Josef Fjord region and show technical ability of a very high order. One would perhaps like to have seen many more of these fine photographs reproduced on a large scale, for comparison of those so treated with those not similarly selected is very much in favour of the bigger picture. The few, for instance, that run up to the edge of the page appear to have succeeded much better in giving a vivid representation of the mountain structure and the surface texture than the much more numerous smaller prints with rather prominent and often distracting white surroundings. Clear and precise statements accompany each photograph and special maps and indexes are also provided which make it very easy either to locate where particular photographs were taken or alternatively to trace down any wanted subject. A temptation to select some of the photographs for special mention has had to

be resisted as so many of them are of first-class merit, both as photographs and as illustrations of scientific value. Accompanying this section of the book is a descriptive account of the voyage itself and of some of the more important events and discoveries. Among the latter was the interesting verification that the stranded Kjerulf Fjord icebergs have their source in Ice Fjord, and the demonstration that their route after calving from the parent glacier has been not outwards to the outer coast as might perhaps have been expected, but westwards into the innermost parts of the great fjord complex.

Professor Bretz in the short time available had an almost impossible task and it must have been extremely difficult to select from among the many problems confronting him. In spite of this embarrassment he has achieved a notable success and has written what is perhaps not only the most important contribution to East Greenland physiography in recent times but also to Arctic physiography generally. Special attention may be directed to the photographs and remarks illustrating glacier movement, and also to the detailed investigation of the problem of raised shore-lines (described frankly as an inconclusive study). Of importance also is his acceptance of the view that the fjords represent drowned valleys of erosion; in his own words, "the fiords are glacial canyons, eroded largely beneath a cover of the continental ice sheet; some *de novo*, most of them greatly modified stream valleys." Mystery Valley, formed presumably by glacial erosion beneath the inland ice cover, is thus in sharp genetic contrast with the precipitous-sided Nordenskiöld Glacier valley and the other great rock walls such as Ättestupan (of which there is a magnificent photograph on p. 231). This thesis of the development of fjords beneath an ice-sheet is one of the most important points in the paper and will no doubt receive more extended treatment at a later date. It is accompanied by an equally interesting and reasonable explanation of the absence of corries on the fjord walls; and final paragraphs comparing the Greenland with the Norwegian fjords serve to round off and accent this crisply written and informative study. J. M. W.

## PHYSICAL AND BIOLOGICAL GEOGRAPHY

GRAVITY EXPEDITIONS AT SEA, 1923–1930. Vol. I. By F. A. VENING MEINESZ. The Expeditions, the Computations and the Results. *Delft: Publication of the Netherlands Geodetic Commission* (*Boekhandel: J. Waltman*) 1932. 12×9 *inches; 110 pages; illustrations and maps*

GRAVITY EXPEDITIONS AT SEA, 1923–1932. Vol. II. Report of the Gravity Expedition in the Atlantic of 1932 and the interpretation of the results. By F. A. VENING MEINESZ, with the collaboration of J. H. F. UMBGROVE and PH. H. KUENEN. *Delft: Publication of the Netherlands Geodetic Commission* (*Boekhandel: J. Waltman*) 1934. 12×9 *inches; 208 pages; maps, diagrams, and tables of Isostatic Reductions* (60 *pages*)

ERGEBNISSE DER SCHWERKRAFTBEOBACHTUNGEN AUF DEM Meere in den Jahren 1923–1932. By F. A. VENING MEINESZ. (Sonderdruck aus *Ergebnisse der Kosmischen Physik*, II Band.) *Leipzig: Akademische Verlagsgesellschaft M.B.H.* 1934. 9×6 *inches; 152–212 pages; diagrams and maps*

In this work Professor Meinesz gives the final results of nearly five hundred measurements of gravity made by him in the submarines of the Dutch Navy between 1923 and 1932, and discusses their significance. As is well known, Professor Meinesz devised methods of great ingenuity for making gravity measurements with pendulums at sea. The technique of the measurements has

been fully described in an earlier publication and is not discussed in detail in this work.

The first volume describes the individual voyages, and gives an estimate of the uncertainty of each measurement. The result obtained is usually accurate to about four parts in a million. This is less than the uncertainties in the interpretation which arise from a lack of a detailed knowledge of the form of the sea-bottom. The soundings of the expeditions emphasize the very imperfect state of our knowledge of the depth of the ocean away from the main ship routes, this is particularly noticeable in the west Pacific. The observations fall into two groups. First, a ring of stations completely encircling the Earth, and second, a detailed study of the East Indies. The oceans are found to be approximately in isostatic equilibrium. That is to say, there is the same mass per unit area under a deep ocean as under a continent, the lightness of sea-water being compensated by the greater density of the rocks underlying the oceans.

The equilibrium is not exact however, and wide areas are found in which gravity is 0·02–0·04 cm./sec.$^2$ in excess. The cause of these widespread anomalies is discussed, and it is suggested that the greater radioactivity of continental masses causes the rock to be hotter at a given depth under a continent than under an ocean, and that this produces convection currents rising under the continents and descending under the oceans. This requires a greater density in the matter beneath the rigid shell under the ocean than under the continents. The explanation is plausible, but it is not clear that there is really anything to explain, for the layers beneath the crust may well have enough strength to support the stresses corresponding to these anomalies without yielding. If we take the latter view however we still have to explain why these anomalies occur over the oceans.

Narrow bands are found in which there are very large departures from isostasy, gravity being from 0·1–0·2 cm./sec.$^2$ too small. The most prominent of these occurs along a line running along the southern edge of the East Indies and turning north between New Guinea and the Celebes. These bands of negative anomalies indicate very large departures from equilibrium, and, as would be expected, are associated with tectonic activity. It is suggested that a fold of light crustal matter has been forced down into the heavier layers beneath by compression of the crust. An account of the tertiary geology of the East Indies is given by Professor Umbgrove, and an account of the relation of the anomalies to the submarine topology of this region by Dr. Kuenen.

The reprint from *Ergebnisse der Kosmischen Physik* gives an account in German of some questions discussed in vol 2 of 'Gravity Expeditions at Sea.' That these measurements are an outstanding technical feat is self-evident; they are also a remarkable example of Government cooperation in a project giving no prospect of immediate practical benefits. Without the assistance of the Dutch Navy the gravity survey of the oceans would undoubtedly have been delayed many years.

E. C. B.

## ECONOMIC AND HISTORICAL GEOGRAPHY

UNSERE AHNEN UND ATLANTIS: Nordische Seeherrschaft von Skandinavien bis nach Nordafrika. By ALBERT HERRMANN. *Berlin: Klinkhardt & Biermann* 1934. 9×6 *inches;* 168+[52] *pages; illustrations and maps. M.*5.40

Professor Herrmann has obviously enjoyed writing this book, and his zest has imparted to it much of the swing of a good detective story. Each clue falls slickly into place, and the dénouement works out to the entire satisfaction of the writer. The reader, for his part, is led on gently step by step, to find himself

at the end turning back the pages to discover where he was led astray and delivered into the author's hands.

The book sets out to demonstrate three propositions: the existence of a highly cultured people with a home in Friesland and a colonizing area extending over most of maritime Western Europe, whose influence lasted into the late Bronze Age, and was responsible among other things for the megalithic monuments of Carnac and Stonehenge; the site of Plato's Atlantis in Tunisia, with a civilization planted there by these colonists; and, finally, the transmission thence of all the elements of culture to the eastern Mediterranean, that is to the area in which these elements had previously been supposed to have largely originated. Thus the truth is at last revealed: far from the Orient being the source of light, the first rays of civilization were kindled on the shores of the North Sea (or German Ocean).

There are of course weak links in the chain, of which in fairness it must be said the author is aware, and for which he has ready explanations. The greater part of the book, which deals with the Frisian culture and its disseminators, must stand or fall by the genuineness of a certain chronicle, alleged to be of high antiquity, which, it is asserted, records events from at least 1680 B.C. It is not practical to discuss here in detail this vexed question. There are reasons for suspecting that it is a mid-nineteenth century forgery: certainly much of it dates from that period, but Professor Herrmann claims that it was then merely edited somewhat severely, and that it contains details which are now supported by the results of recent research and could not have been invented by the most inspired forger.

Instead therefore of the accepted idea of the diffusion of culture from east to west, the author boldly substitutes a west-to-east movement. These northerners become the founders of a pre-Hellenic Masilia, the ancestors of the Carthaginians, the colonizers of Atlantis (which in turn becomes the predecessor of Tartessus), the suppliers of the iron found in Mycenian graves (there is no mention of the possible source in the Halys valley), and those from whom ultimately the Greeks learned the art of writing. Reference has already been made in this *Journal* to Herrmann's theory, which is essentially a development of Herr Paul Borchardt's, that the site of Atlantis is to be found in southern Tunis on the shore of the Shatt el Jerid, and, as has been recognized, there is much to be said for this interpretation of the classical sources. He gives here an account of his reconnaissance in 1933, when he found what he believes further excavation will prove to be the site of the Atlantean city. Until that work is carried out the only material evidence for his theory are the pieces of pottery he found there, which have been assigned to the seventh century B.C. This section is the most convincing, and it may perhaps be regretted that it has been interwoven with a more sweeping and controversial theory. As for the origins of Hellenic culture, that is a subject which must be left to the expert archaeologist. Professor Herrmann answers many puzzling questions, but whether his answers are the right ones may be doubted.

These pages are occasionally tinged with a nationalist theory. It is no mean feat to have linked contemporary racial ideals with a solution of the much-debated problem of Atlantis. G. R. C.

# THE MONTHLY RECORD

## MEDALS AND AWARDS, 1934

His Majesty the King has been pleased to approve the award of the Royal Medals as follows: the *Founder's Medal* to Major R. A. Bagnold, for his journeys in the Libyan Desert; the *Patron's Medal* to Mr. W. Rickmer Rickmers, for his long-continued travels in the Caucasus and Russian Turkistan culminating in his leadership of the Alai–Pamir Russo-German Expedition of 1928. The Council have awarded the *Victoria Medal* to Mr. E. J. Wayland, for his work on the Quaternary geology of Uganda and the Rift, and its relation to man; the *Murchison Grant* to Mr. R. P. Bishop, for his surveys in British Columbia and other services to geography; the *Back Grant* to Mr. Wilfred Thesiger, for his journey through the Danakil country, 1933–1934; the *Cuthbert Peek Grant* to Mr. A. R. Glen, for his work in Spitsbergen, particularly his leadership of the Oxford University Expedition, 1933; the *Gill Memorial* to Mr. E. E. Shipton, for his plane-table surveys of the inner Nanda Devi basin and the neighbouring watersheds.

## AWARD OF THE GEOGRAPHICAL ESSAY PRIZE

In the *Journal* for June 1933 it was announced that the Council of the Society had resolved to offer a prize of Ten Pounds annually for an Essay of not more than 5000 words: either a critical survey of recent additions to knowledge in a limited geographical field selected by the writer, or a discussion of some current problem in its geographical aspects. Competitors for the Prize must be registered Internal or External Students reading for Honours in Geography at one of the Universities of Great Britain and Northern Ireland during the academic year within which they submit their Essay. Essays must be submitted during the month of December, the award will be made not later than March 31, and the Prize Essay will be published in the *Geographical Journal* for May or June following.

Four Essays were submitted in December 1933, and twenty in December last, and the prize in the second competition has been awarded to Mr. R. Wallace, student of the University of Cambridge, for an essay on "The Paper Industry of the Pennine Region." Essays in competition for the third award of the prize should be addressed to the Secretary of the Society by 31 December 1935.

## GLACIAL MORPHOLOGY OF BRITISH ISLES

In a monograph entitled "Glazialmorphologische Studien in den Gebirgen der Britischen Inseln," Herbert Louis discusses the last or Würm glaciation in these islands, of which a record is left in the so-called "Newer Drift" (*Berliner Geographische Arbeiten*, Heft 6, 1934). The author made a tour of many of the glaciated areas, and had the advantage of meeting several eminent geographers and geologists while in this country.

Perhaps the most interesting part of his work relates to the height of the snow-line during the last Ice Age, a knowledge of which throws light on certain climatological questions and is helpful in distinguishing between morphological effects due to local mountain glaciations and those due to the ice-sheet. The height of the snow-line during the Würm period was about 400 metres above sea-level for the British Isles as a whole, only 50 to 100 metres higher than it appears to have been at the earlier maximum glaciation. Since at the present day the mean temperature of the coldest month is in most places a little above the freezing-point at 400 metres, the glaciation must have been caused by a great lowering of temperature, and no increase of precipitation under present conditions in these

islands could bring one about. An indication however that the prevailing winds were from the Atlantic then as now is given by the noticeably lower level of the snow-line on the west coasts of Ireland and Scotland, where it approximated to sea-level, than elsewhere. In England the uplands of Dartmoor and Exmoor and the southern end of the Pennine range, at about 600 metres, just failed to reach the snow-line. The Peak district uplands appear never to have been glaciated though moraines left by the lowland ice-sheet from the North occur up to 400 metres on the flanks of the hills. It is curious that the author should make no allusion to what seems a necessary inference from this: that the ice-sheet from Scotland and Norway which overspread the Midlands and East Anglia must have lain some 500 metres beneath the climatic snow-line, receiving, that is to say, no increment from the winter snowfall. The anomaly is much more remarkable and puzzling than the somewhat analogous one presented by a mountain glacier penetrating well below the snow-line. The explanation would indeed be very difficult without reference to a map after Peake and Fleure in the *Zeitschrift für Rassenkunde* (Bd. I, Heft I (1935), p. 38), which shows England joined to the Continent in the early post-glacial period along a wide front stretching from Yorkshire to Sussex. This would provide for the possibility of continental summer heating allowing warm air from ice-free regions to the south to advance over the English ice-sheet and remove the winter snow-cover; whereas had Britain been an island under glacial conditions the snow-line would have been very low everywhere and the ice-sheet would have probably extended south of the Thames.

The author proceeds to consider some of the mountainous areas in detail, pointing out that the Ben Nevis region, the Lakes, Snowdon, the Wicklow Mountains, and other systems show traces of intense local glaciation with active corrie-formation. He distinguishes between corrie glaciers which were active during the whole of the Würm glaciation and those which, through being submerged by an ice-sheet during the middle of the period, were only active early or late. He estimates that at the height of the period there were 200,000 cubic kilometres of ice of British origin fed by an area above the snow-line amounting to 30,000 square kilometres, and that this volume of ice, on certain assumptions as to mean annual precipitation, would have required 2500 years to develop.

## TRAVELLERS IN THE HADHRAMAUT

It was reported in the Press some weeks ago that Miss Freya Stark was seriously ill in Shibam and that an R.A.F. doctor had been sent to bring her back to Aden by aeroplane. From letters which we have been allowed to see it is now possible to piece together these fragments of information into a coherent whole. It seems that during the early days of February Miss Stark made excellent progress with the Arab chiefs of the Hadhramaut, and she had obtained promises of help for any expedition she chose to make. Her diary speaks of "most interesting places besides Shabwa, and everybody most kind and friendly." And later, in a letter dated February 12 from Wadi Du'an: "I have got so far much slower than I intended, because I landed in an epidemic of measles and went down with them in Wadi Du'an. . . . They were so kind to me and luckily my constitution is strong: as soon as the worst was over, I rode up the Wadi to Hajarain and then the Al Kaf brothers sent a car and we came in two days up here in this most fantastic valley in the world. It is worth taking a lot of trouble to see it, and I am hoping to have time to do so while I convalesce. At present I am in bed in their guest-house and very comfortable, all beautifully clean, pure water, a swimming-pool if I am fit to use it; and the pure untouched middle ages all round. Shabwa is a measurable distance—only three or four days from the most

westerly town of the Wadi, and I am promised proper *rafiqs*. Since Hijaz and Yaman are at peace, the route 'Abr–Najran–Dawasir is used once more and it is 24 days from here to Makka." In another letter, after describing her rescue from Wadi Du'an by an R.A.F. aeroplane after sixteen days' acute measles and consequent heart-weakness, Miss Stark writes: "I have done nothing, of course, in any way useful, as I was only to begin after Shibam—but I have a good idea now of where I *think* the old routes passed through Hadhramaut itself, and would know where to look for traces: the people have all been charming to me, and the Wadi I feel is full of my friends."

Miss Stark is at present in hospital in Aden and the condition of her heart will probably prevent her doing any more active exploring in the Hadhramaut for the rest of the year; but the doctors' reports are reassuring. Meanwhile we have been permitted to quote a letter from another traveller in the Hadhramaut, Mr. W. H. Ingrams, whose article on Hadhramaut house-building appeared in last month's *Journal*. In his letter Mr. Ingrams describes how he and his wife arrived by car to stay with one of the rich landowners of the district. "We hooted outside the gate at a quarter to eight. It was opened and we drove to a palace decorated with flags and illuminated all over with electric light. Inside this marvel a perfectly good Egyptian butler—in European clothes—led us to the bedroom (two brass beds with pink *crêpe-de-chine* pillows) and then to the bathroom. There was a marble bath in one corner, proper wash-basin with running water, shower-baths, and, wonder of wonders, a real 'pull and let go.' An amazing set of pink enamel brushes and combs was produced, and I was asked what kind of hair-wash I would like! I began to feel distinctly out of place without my tails! . . . English carpets and masses of gilt mirrors, chandeliers, and *argentiers* full of marmalade dishes, etc. Electric fans and iced drinks and telephones finished me off and I began to feel it would have disappeared like Aladdin's palace by morning. However we woke up to the butler producing tea in the morning, were put into a car and driven to the family swimming-bath, about 30 feet long, and every luxury like changing-rooms, divans, etc., all round. And yet . . . you can watch a battle almost every morning outside the city walls and if you are a local you can't drive 5 miles without an escort in your car."

## CLIMATE OF THE ALASKA–YUKON PLATEAU

In the *Monthly Weather Review* for August 1934 Mr. R. L. Frost gives "A Climatological Review of the Alaska–Yukon Plateau," which is full of interesting information. This region, drained by the river Yukon, is described as a high semi-arid plateau between the little-known Endicott Mountains continuing on the north of the line of the Rockies, and ranges under various names, including the Mount McKinley group, continuing the Coast Range on the south. Various towns and settlements dependent on the gold industry, most of them in Alaska but a few in Yukon Territory, are scattered over the area and have quite long meteorological records which form the basis of the discussion. Aviation is playing a large part in the development of the country.

The subsoil of practically all the interior of Alaska is permanently frozen to a great depth, and the outstanding character of the climate is intense winter cold. It is indeed not unlikely that a close network of stations might disclose a local "pole of cold" in North-West America comparable with Verkhoyansk in North-East Asia. The coldest month in the record was December 1917 with a mean temperature at Dawson in Yukon as low as −51° F., but the extreme minimum temperature occurred in January 1886, viz. −76° at Tanana in Alaska, and −80° at Fort Reliance, near Dawson. A temperature lower than −95° was apparently indicated by a self-registering thermometer left at 15,000 feet on Mount

McKinley by Hudson Stuck in 1913, which, if reliable, surpasses the Verkhoyansk minimum for the Earth's surface.

Much low cloud accompanies the intense winter cold, and by checking radiation may have the effect of making it less intense than it otherwise would be. The severity of the winter to human beings is enhanced not only by the darkness but also by dense and prolonged fogs. On the other hand, since high winds and gales are rare, drifting blizzards are quite uncommon. The snowfall is light but by spring has accumulated to a depth of 3 or more feet. At temperatures far below zero Fahr. a heavy mist-like snow sometimes falls. Aeroplane observations reveal a noticeably warmer stratum of air above the very cold surface air. The summer weather is ordinarily cool and cloudy, but spells of intense scorching heat are liable to intervene in late June, July, or early August, with maxima near or over 100° F. Evaporation is then very active from the mossy surface, and cumulo-nimbus clouds develop with thunder showers. In August 1930 as much as 8 inches of rain fell at Fairbanks.

It is remarked that only in respect of low average annual precipitation of about 12 inches can the Alaska–Yukon plateau be called semi-arid, since the winter snow-cover, the spring floods, and the swampy summer surface with frequent showers all combine to give an appearance of abundant moisture. Reference is made to the paradox that though on very cold winter days (−50° F.) the air may be saturated and there may be dense mist the actual amount of vapour in the air is so small that the percentage of saturation would be extremely low at ordinary positive temperatures. Humidity however is a paradox everywhere. Thus in England the air normally contains about twice as much vapour in summer as in winter but is 10 per cent. farther from saturation. Both absolute and relative humidity conditions have important meteorological and physiological bearings, and the two concepts should be more carefully distinguished than is customary even among meteorologists.

Brilliant and complex haloes are a pleasing feature of Alaskan skies, and a large number of beautiful aurorae relieve the Arctic winter gloom. Constant daylight in summer compensates in some measure for the short vegetative period of such crops and trees as mature, but the gnats and mosquitoes are a merciless scourge.

## JOURNEY IN BRAZIL AND BRITISH GUIANA

We have received a reprint from the *Agricultural Journal* of British Guiana of an article by Dr. J. G. Myers which summarizes his observations on a journey in 1932 from Pará to Georgetown *via* Manaos, the Rio Branco, Mt. Roraima, and the Rupununi. His object was to study the possibility of biological control of pests, but this paper is of more general interest—"the miscellaneous impressions of a travelling agricultural ecologist." He was struck with the primitive character of many of the sugar plantations around Pará, the cultivators moving, after three or four crops, from one strip of virgin forest to another. A visit to the savannas of the Ilha de Marajó showed that their vegetation is intermediate between that of the coastal savannas of British Guiana and that of the Rio Branco. On the journey to Manáos great beds of floating grass were seen: these are one of the original homes of the small moth-borer, which is estimated to destroy annually about 20 per cent. of the British Guiana sugar crop. An effective parasite has however been recently introduced. Dr. Myers observes that Japanese colonization is proceeding on quite a considerable scale on the lower Amazon, where they are experimenting with many tropical crops.

Dr. Myers gives an interesting description of the up-to-date settlement of Boa Vista, which has been established about 120 miles up the Rio Tapajoz on

the great Ford rubber concession. The inhabitants, 94 per cent. Brazilians, were supplied with all modern appliances and the community was said to be using 300,000 gallons of water a day. A large-scale attempt had been made to use commercially the timber obtained during the clearing, but it had to be abandoned as it failed to survive long-distance transport. Many of the activities of this settlement had been reduced by 1933. The failure of the wild rubber industry was reflected in the squalid conditions of Manáos, and in the depression of the cattle industry which centres around Boa Vista on the Rio Branco.

Discussing the Rupununi savannas the author remarks that at present they are greatly under-stocked with cattle, but that unless the pastures are correctly managed, this area must share the fate of the older savannas of Brazil and Venezuela, where overstocking has led to degeneration of the vegetation and the spread of inedible weeds. He believes that the periodic burning of the savanna as practised at present is not detrimental. Until recently the Rupununi area was a "biological island," and it would be advisable to take some steps to prevent the introduction of pests.

Considerable difficulty was experienced in obtaining porters from the Rupununi to Mount Roraima as severe fevers were prevalent, and one village had also lost all its horses. Of the savanna lands traversed, that of Kurasabai is said to carry the finest cattle. On the return to the Rio Branco, the author was struck by the great difference between the health of the Brazilians and that of the Indians living practically under the same conditions, and suggests that the good health of the latter is due to their heavy consumption of native drinks rich in yeasts. The cattle trail from the Rupununi to the Berbice savannas is described as a "magnificent piece of work": the main problem now is to provide sufficient pasturage in the holding paddocks.

## SIXTEENTH-CENTURY DUTCH HYDROGRAPHER

Captain D. Gerney has presented to the Library a reprint of his article in the *Compas d'Or*, Antwerp, on the Dutch cartographer, Aelbert Haeyen, or Hendricksz. Haeyen is known almost solely as the author of the 'Amstelredamsche Zeecaerten,' a collection of charts and nautical directions which went through several editions between 1585 and 1613. The author has endeavoured, without much success, to collect the facts for a biographical sketch of Haeyen: it is surmised that he was born at Haarlem about 1550. As a practical seaman he gained a considerable reputation, so that the authorities at Amsterdam, when they wished to have a volume of nautical instructions compiled, entrusted the task to him. The result was the 'Amstelredamsche Zeecaerten,' which dealt with the coasts of the North Sea from the Pas de Calais to Cape Skagen. Haeyen planned to publish four further parts describing the whole navigation from east to west. Unfortunately, the authorities withdrew their support, and nothing more was published. This rebuff appears to have embittered him, especially against stay-at-home theorists, and he later became involved in a violent controversy with Peter Plancius.

The cause of this withdrawal of support was very probably the publication of the first part of Waeghenaer's well-known 'Spieghel der Zeevaert' in 1584, followed by the second in 1585, which made any similar work appear unnecessary to the Burgomasters. The author has examined the work of Haeyen to determine whether this implied superiority of Waeghenaer's 'Spieghel' was justified. The fifty-six short chapters of text contain much varied information on the recognition of the coasts, currents, and banks, the routes to be followed between the ports, the entrances to the harbours, and similar practical details, some of which were furnished by his acquaintances. The book also contains five charts,

each covering two folio pages, engraved by Herman Muller. The arrangement of detail in Haeyen is more logical than in Waeghenaer, and the former's descriptions are generally in much greater detail. The information given in the two works differs considerably, but it is not possible now to determine which was the more correct at the time. The abundant and precise details in Haeyen inspire confidence, especially as in many cases the source of his information is quoted. Haeyen's charts are on a slightly smaller scale than Waeghenaer's, and in places are rather more generalized, but they have one useful additional feature: lines of bearings are drawn from prominent objects on shore to the positions of sandbanks and other obstacles to navigation. The 'Zeecaerten' was also highly appreciated by contemporaries, particularly by William Jansz. Blaeu. The author therefore is justified in maintaining the superiority in many respects of Haeyen to Waeghenaer, and in regretting the short-sightedness of the Burgomasters which prevented the completion of the work.

## A NEW MOUNT EVEREST EXPEDITION

The Mount Everest Committee has received, through the Government of India and the Secretary of State, the consent of the Tibetan Government for a British Expedition to Mount Everest during 1935–36.

The Committee have accordingly arranged to send this summer to Mount Everest a small reconnaissance expedition in preparation for a further attempt on the summit in the early summer of 1936 under the leadership of Mr. Hugh Ruttledge. The Reconnaissance will be led by Mr. E. E. Shipton and will include Mr. H. W. Tilman, Doctor Charles Warren, Mr. E. H. L. Wigram, Mr. L. V. Bryant (from New Zealand), Mr. Michael Spender, and one or more members from India of the Himalayan Club not yet finally selected.

## OBITUARY

### AXEL WILHELM WALLÉN, PH.D.

We record with deep regret the death on February 24 of Dr. Axel Wallén, an Honorary Member of the Society since 1930. Dr. Wallén, who was born at Goteborg in 1877, was a leading figure among Swedish meteorologists and hydrologists, though his interests were not exclusively confined to those subjects. Much of his work was directed to the forecasting of floods and storms, but he had also studied the relations of man and climate. In 1907 he became President of the Swedish Hydrographical Bureau, and in 1918 Director of the Meteorological-Hydrographical Office. He was also prominent as a representative of his country in international scientific circles, having been largely responsible for the local arrangements of the very successful meeting of the International Union of Geodesy and Geophysics at Stockholm in 1930, and President of the Meteorological Association of that Union since 1931. He was for ten years Secretary of the Swedish Geographical and Anthropological Society, and as editor of their publication, the *Geografiska Annaler*, from its inception in 1919, he contributed much to the development of all branches of physical geography. He represented the Swedish Society at the celebration of our Centenary in 1930.

## MEETINGS: SESSION 1934–35

Tenth Evening Meeting, 1 April 1935. The President in the Chair

*Elections:* Mrs. Beatrice Frances Jarvis Agar; Miss Julia A. S. Butler; Herbert I. Callon; The Reverend C. R. Vallance Cook; Miss Audrey Marion Freese; Iver Lunn; Alexander Murray McPhee, B.A., F.R.E.S.; Tun Nyoe, B.A.

*Paper:* Dr. Knud Rasmussen's Contributions to the Exploration of the South-East Coast of Greenland. By Captain Gabel-Jørgensen

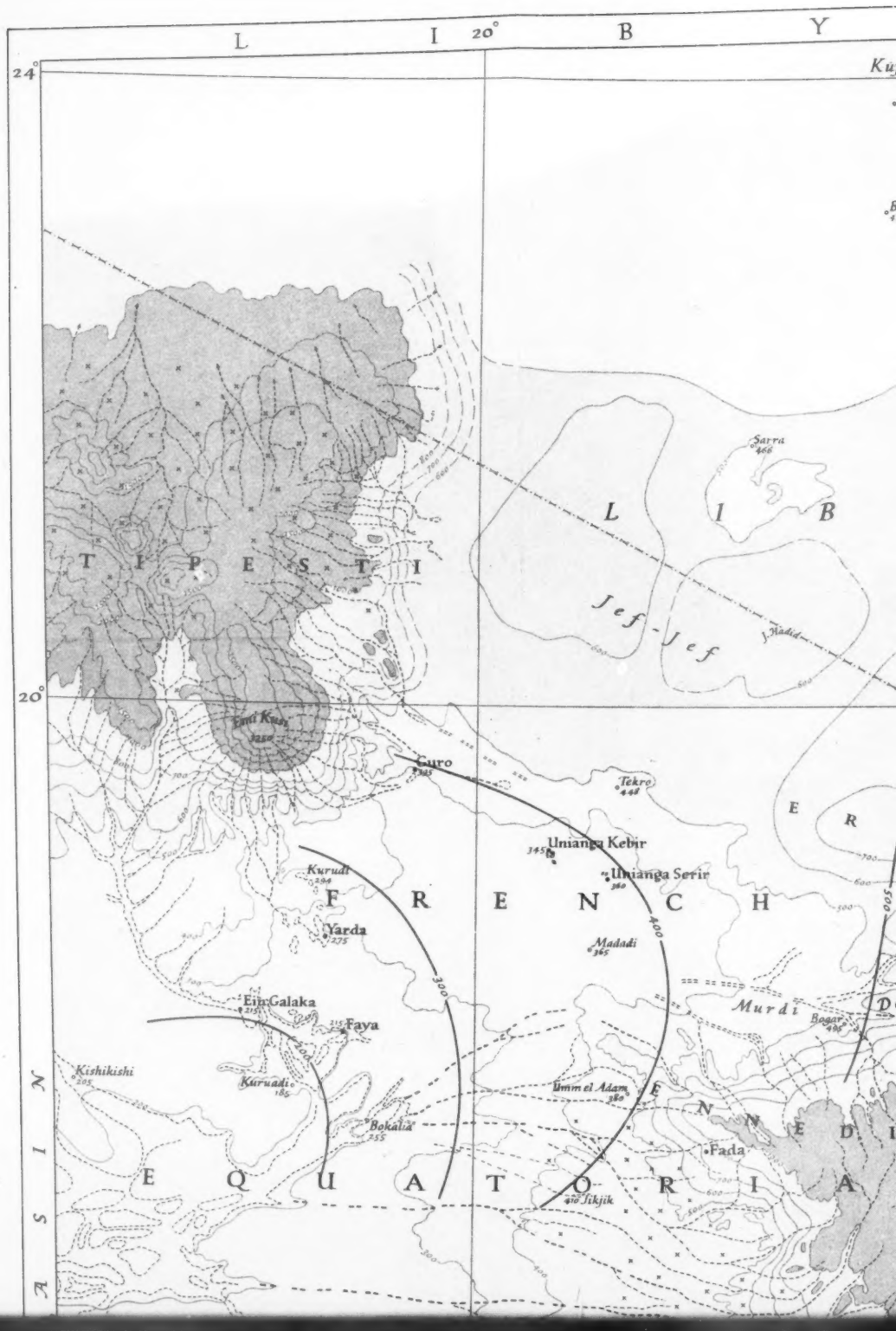
Sixth Afternoon Meeting, 8 April 1935. The President in the Chair

*Paper:* Ice-Cap Studies and Glacier Physics. By Professor Hans Ahlmann

Eleventh Evening Meeting, 15 April 1935. The President in the Chair

*Elections:* Mrs. Gertrude Fanny Bentall; Arthur Edward Lloyd Cox, B.A.; John Crawford; Professor Richard Finsterwalder; Hugh Telford Gibb; Horace Richard Neate; Claud Wyndham Hurry Riches; Miss Ruth B. Roy

*Paper:* The Lake Rudolf Rift Valley Expedition. By Mr. V. E. Fuchs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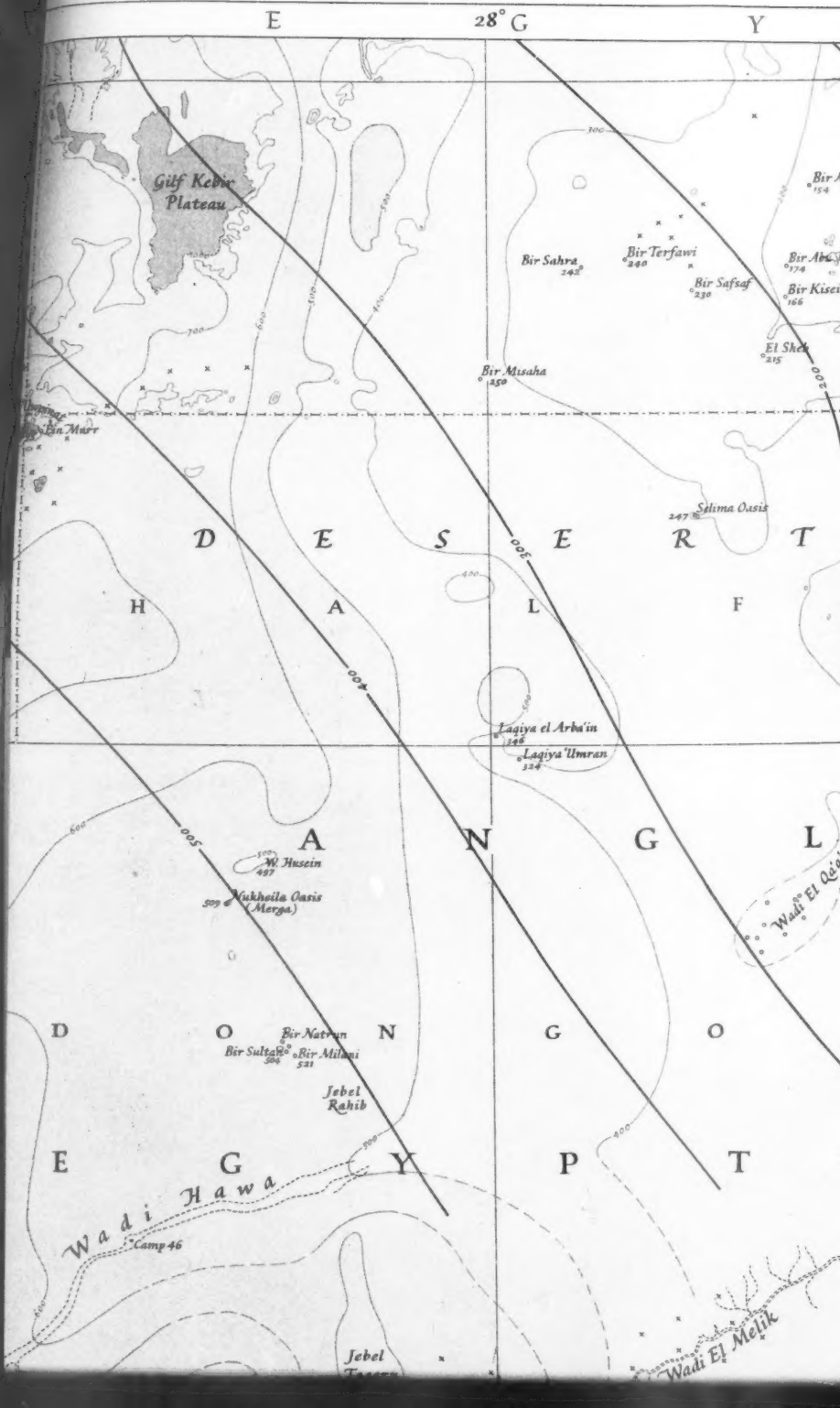
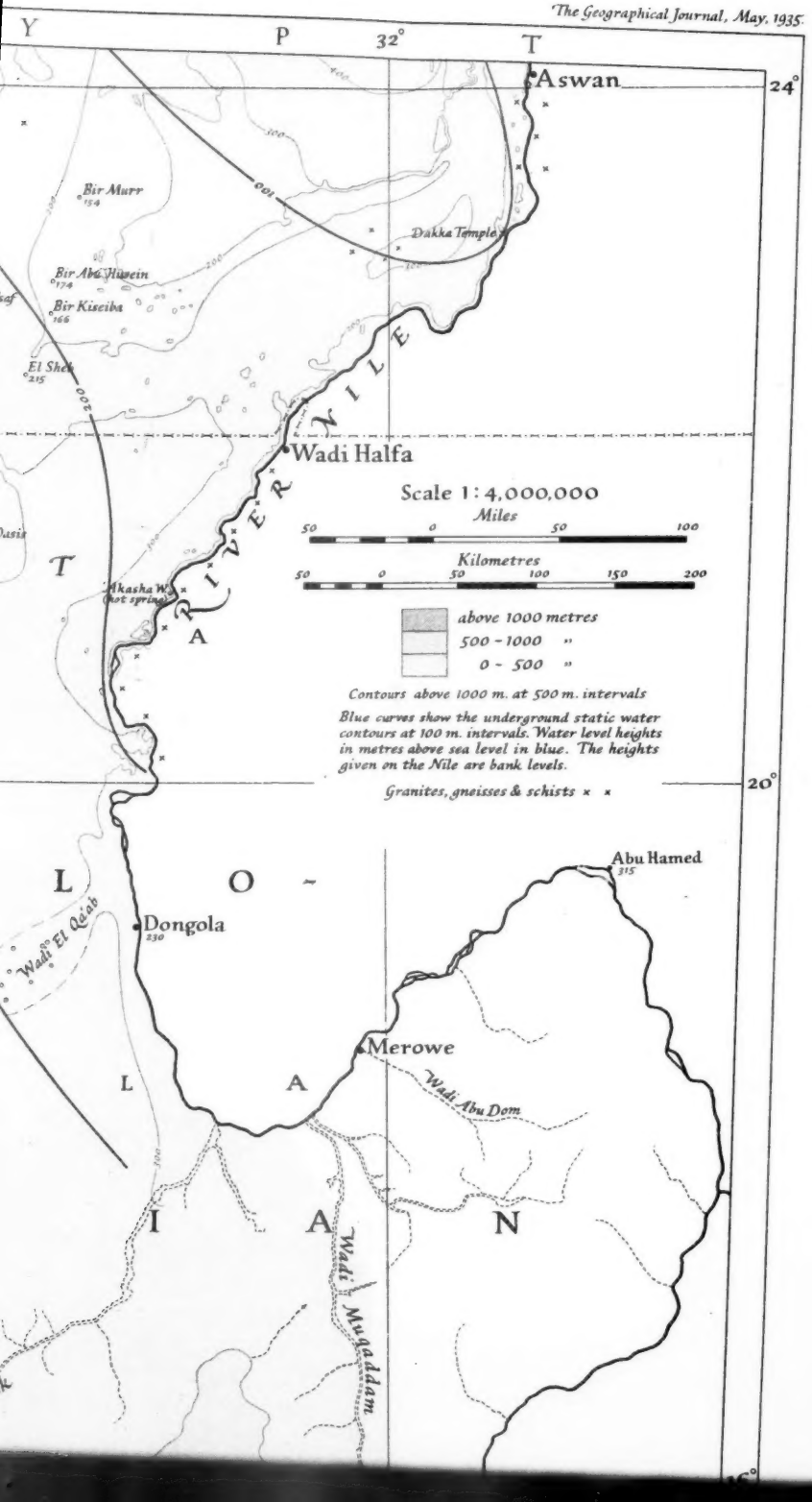
To accompany a paper by Dr. K.S. Sandford

DAN & ADJACENT TERRITORIES
a paper by Dr. K.S. Sandford

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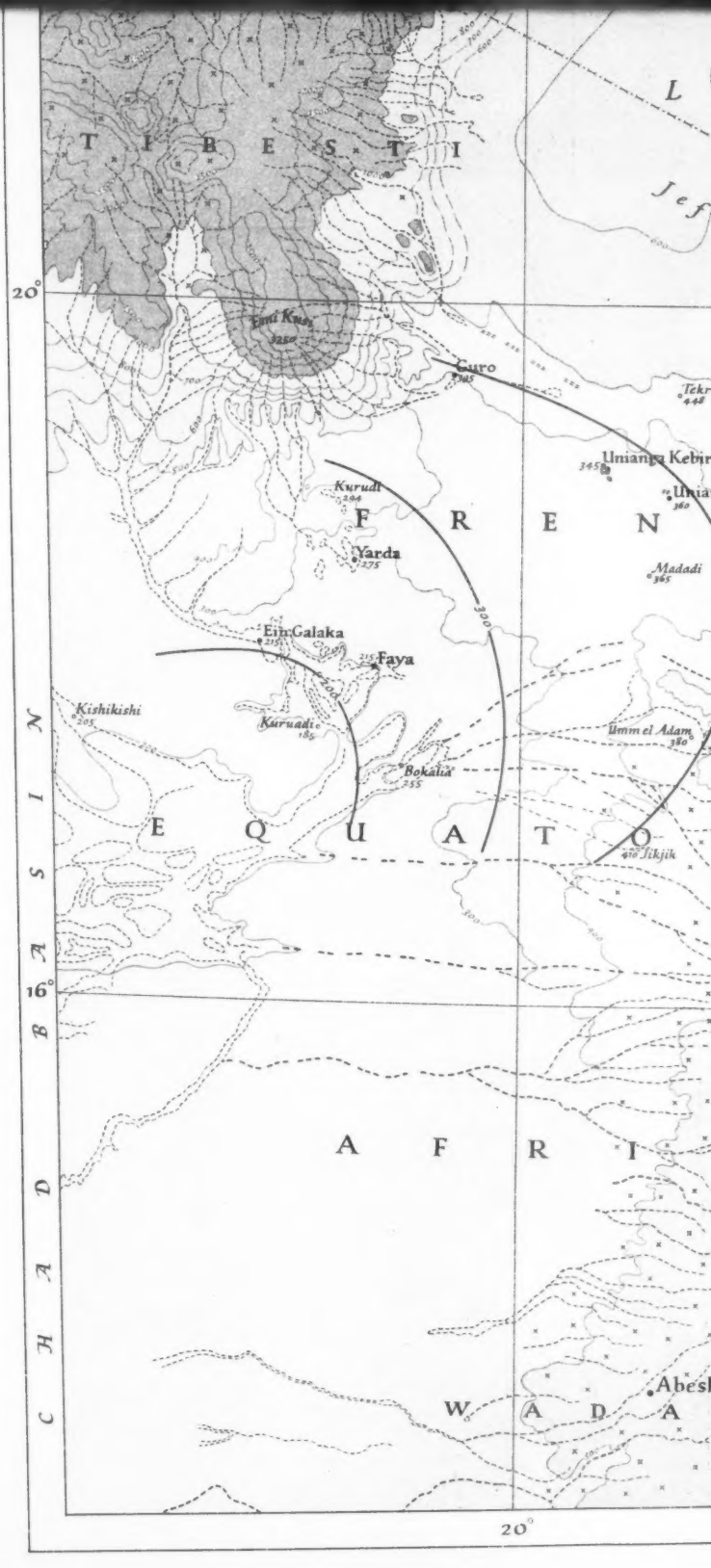
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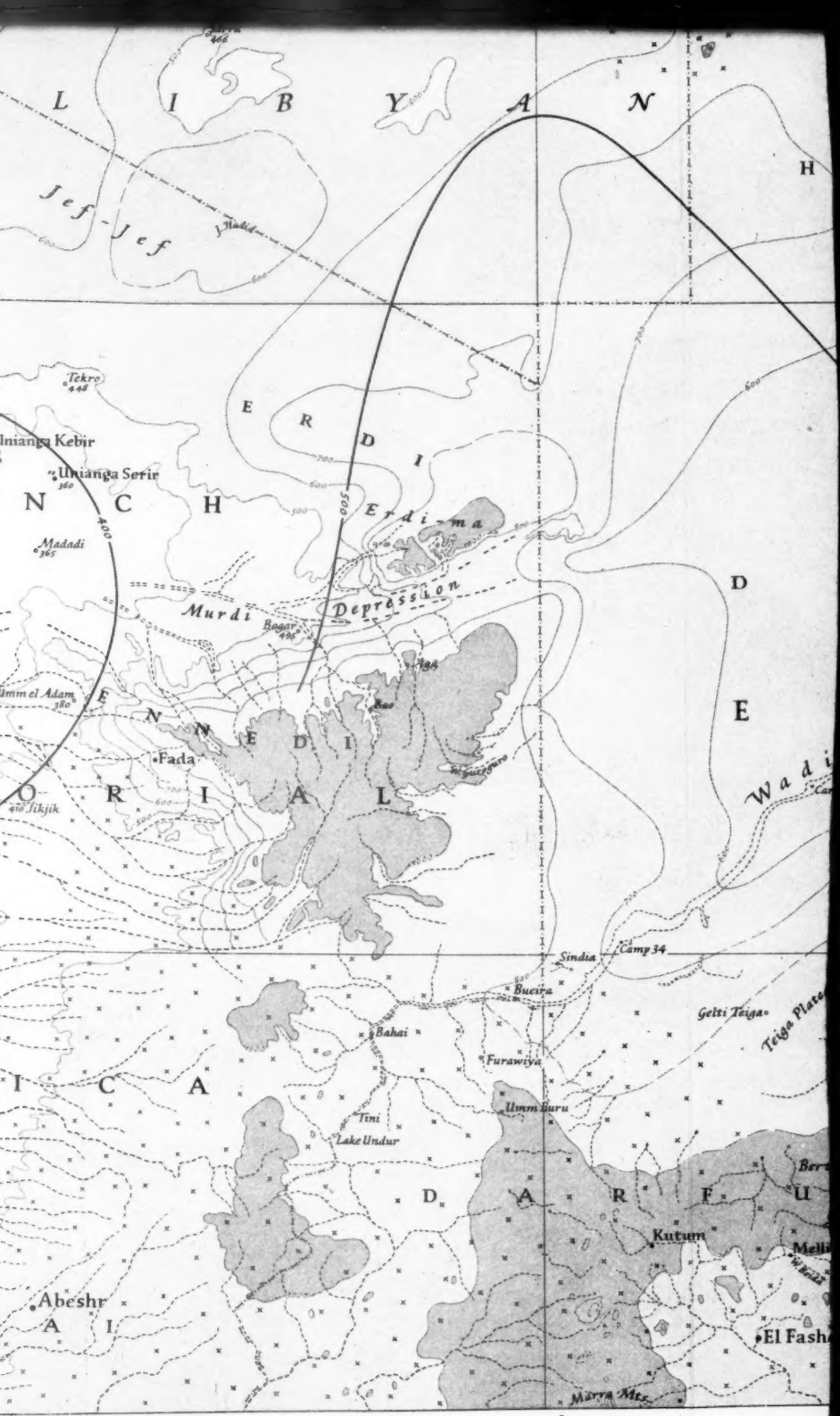


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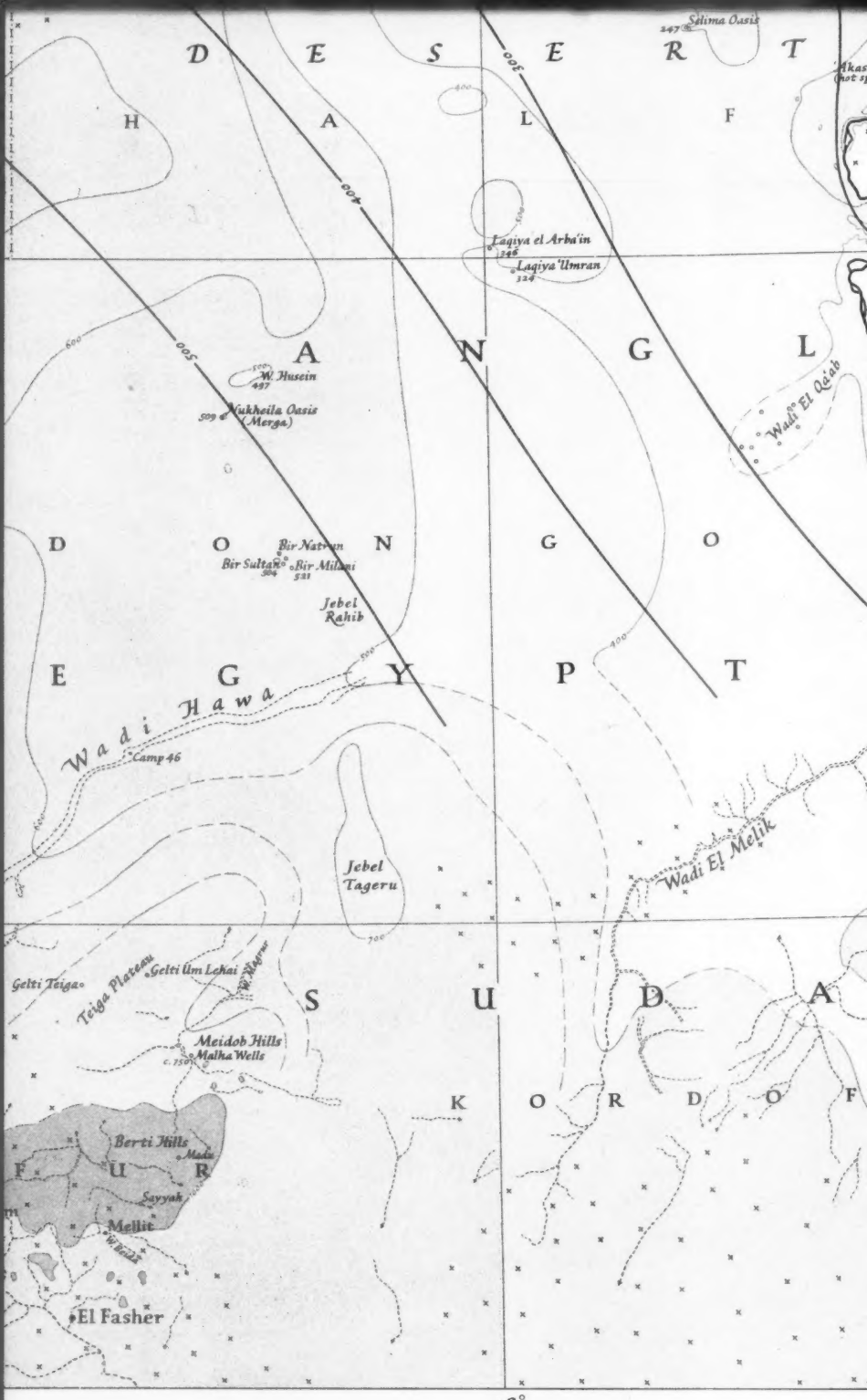


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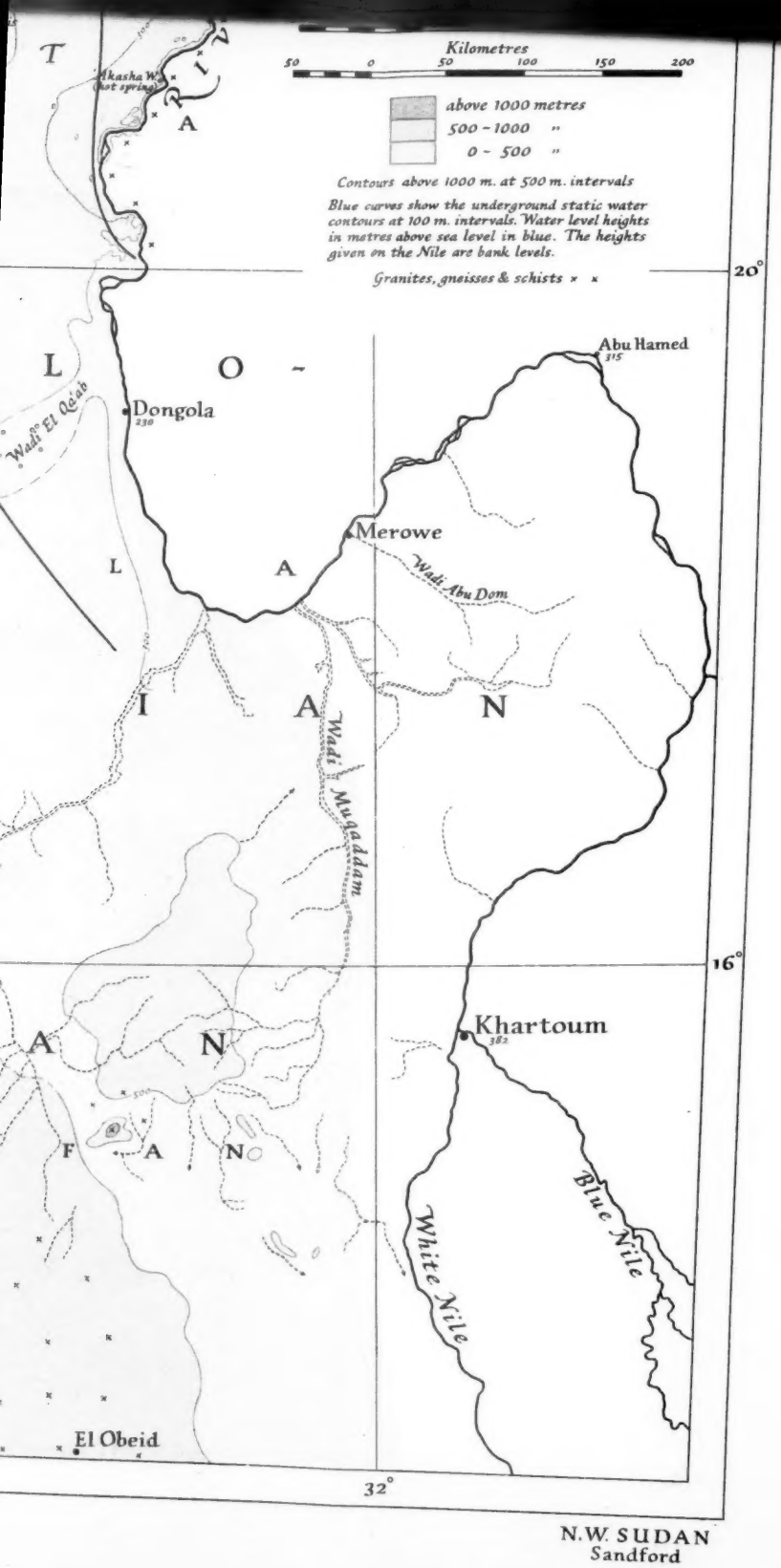


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